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Programmer's Manual for EXPLORE-I
A River Basin Water Quality Model
Appendix C

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APPENDIX C

PROGRAMMER'S MANUAL

For

EXPLORE-I: A RIVER BASIN WATER QUALITY MODEL

by

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ENVIRONMENTAL PROTECTION AGENCY

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SUMMARY

EXPLORE-I, the Battelle-Northwest water quality model, is a computer program which simulates the dynamic hydraulic and water quality characteristics of a river basin. It can be used to study the effects of various flow conditions, waste discharge and treatment schemes on the water quality levels of lakes, reservoirs, streams, and rivers. This Programmer's Manual provides the basic programming requirements of the EXPLORE-I codes. Included are flow diagrams, variable definition tables, program listings and brief descriptions of the main subroutines.

APPENDIX C

CONTENTS

	Page
SUMMARY	iii
FIGURES	v
TABLES	vii
PROGRAMMER'S MANUAL: INTRODUCTION	C-1
RIVER BASIN HYDRAULIC CODE	C-1
Hydraulic Input Program Description	C-1
Hydraulic Calculations Program	C-7
RIVER BASIN QUALITY CODE	C-7
Quality Input Code Description	C-87
Quality Calculational Code Description	C-89
RESERVOIR MODELING CODES	C-183
Thermal Hydraulic Code	C-183
Quality Simulation Code	C-186
Remarks	C-186
CONCLUSION	C-186
REFERENCES	C-283

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FIGURES

Page

C-1 RELATIONSHIP OF THE HYDRAULIC INPUT CALCULATION AND OUTPUT CODES C-2

C-2 FLOW CHART OF SUBROUTINE INH C-4

C-3 FLOW CHART OF TIDCF C-6

C-4 FLOW CHART OF SUBROUTINE PICTUR C-8

C-5 FLOW CHART OF SUBROUTINE HYDCAL C-9

C-6 FLOW CHART OF SUBROUTINE GENFUN C-11

C-7 FLOW DIAGRAM OF SUBROUTINE HYDPLT C-12

C-8 LISTING OF THE HYDRAULIC INPUT COMPUTER PROGRAM FOR EXPLORE-I C-13

C-9 LISTING OF THE HYDRAULIC CALCULATIONAL COMPUTER PROGRAM FOR EXPLORE-I C-47

C-10 RELATIONSHIP OF QUALITY INPUT AND CALCULATION CODES C-79

C-11 FLOW CHART FOR MAIN QUALITY INPUT PROGRAM QMAINT C-88

C-12 FLOW CHART FOR QUALITY INPUT SUBROUTINE INQ C-90

C-13 FLOW CHART FOR MAIN QUALITY PROGRAM CLEAN C-91

C-14 FLOW CHART FOR REAERATION SUBROUTINE REA C-92

C-15 FLOW CHART FOR TRANSPORT CALCULATION SUBROUTINE TRANSP C-93

C-16 FLOW CHART FOR TEMPERATURE CORRECTION SUBROUTINE TEMPER C-94

C-17 FLOW DIFFERENTIAL EQUATION SOLUTION SUBROUTINE DIFEQ C-94

C-18 FLOW CHART OF DERIVATIVE CALCULATION SUBROUTINE DE C-95

Page

C-19 FLOW CHART FOR ALGAE DERIVATIVE CALCULATION SUBROUTINE ALG C-96

C-20 FLOW CHART FOR PHOSPHORUS DERIVATIVE CALCULATION SUBROUTINE PHO C-97

C-21 FLOW CHART FOR NITROGEN DERIVATIVE CALCULATION SUBROUTINE TIN C-98

C-22 FLOW CHART OF SUSPENDED ALGAE OXYGEN PRODUCTION SUBROUTINE SPR C-99

C-23 FLOW CHART FOR ATTACHED ALGAE PRODUCTION SUBROUTINE APR C-99

C-24 FLOW CHART FOR BOD DERIVATIVE CALCULATION SUBROUTINE BOD C-100

C-25 FLOW CHART FOR BENTHIC BOD DERIVATIVE CALCULATION SUBROUTINE BEN C-100

C-26 FLOW CHART FOR TOC DERIVATIVE CALCULATION SUBROUTINE TOC C-101

C-27 FLOW CHART FOR DISSOLVED OXYGEN DERIVATIVE SUBROUTINE DOX C-101

C-28 FLOW CHART FOR TOXIC COMPOUND SUBROUTINE TOX C-102

C-29 FLOW CHART FOR LINEPRINTER SUBROUTINE PRINT C-102

C-30 LISTING OF THE QUALITY INPUT COMPUTER PROGRAM FOR EXPLORE-I C-117

C-31 LISTING OF THE QUALITY CALCULATIONAL COMPUTER PROGRAM FOR EXPLORE-I C-150

C-32 FLOWCHART OF CLIMA - GENERAL METEOROLOGIC AND HYDRAULIC DATA INPUT CODE C-184

C-33 FLOWCHART OF TERMA - MULTI-SEGMENT DEEP RESERVOIR SIMULATION CODE C-185

C-34 FLOWCHART OF AQUA, RESERVOIR QUALITY SIMULATION CODE C-187

Page

C-35 PROGRAM LISTING FOR CLIMA C-193

C-36 PROGRAM LISTING FOR TERMA C-214

C-37 PROGRAM LISTING FOR AQUA C-245

TABLES

Page

C-1 Variable Definition for Hydraulic Code C-80

C-2 Variable Definition for Quality Code C-103

C-3 Variable Definition for Reservoir Quality Code C-188

APPENDIX C

PROGRAMMER'S MANUAL

INTRODUCTION

The Battelle-Northwest EXPLORE-I water quality model is a digital computer program which can simulate the dynamic hydraulic and water quality characteristics of a river basin. Detailed descriptions of the EXPLORE-I code are given in the main report and instructions for operation of the code are found in the User's Manual, Appendix B. This appendix provides additional information on the programming details of the code and contains the program listings.

RIVER BASIN HYDRAULIC CODE

The EXPLORE-I hydraulic code consists of two separate executable programs, an input code and a calculation code. These codes must be executed in sequence. Figure C-1 shows the relationship of these programs.

Hydraulic Input Program Description

The executive program is IMAINT. This program serves only to make I/O device assignments and to call the main input subroutine INH. Subroutine INH reads in the input data necessary for the hydraulic calculations. INH calls subroutine TIDCF when a fit of the stage versus time data is required and subroutine REGRES when it is necessary to fit time varying data on controlled nodes or flow hydrographs. Figure C-2 shows a flow chart for subroutine INH.

Subroutine REGRES is a standard polynomial regression program taken from Reference C-1. This program reads in an array of M ordered data points and does a user-specified set of Nth order polynomial regressions ($1 \leq N < 5$). In each case print and plot data indicating the quality of the fit are produced. REGRES calls on functions REGR and SIMUL for the regressions and on subroutine PICTUR for the line-printer plots. Details of this subroutine can be found in Reference C-1.

Subroutine TIDCF calculates the coefficients of the tidal function H(t) = A1 + A2*SIN(t) + A3*SIN(2t) + A4*SIN(3t) + A5*COS(t) + A6*COS(2t) + A7*COS(3t) from input values of H and T by a least squares procedure. Figure C-3 is a flow chart of TIDCF.

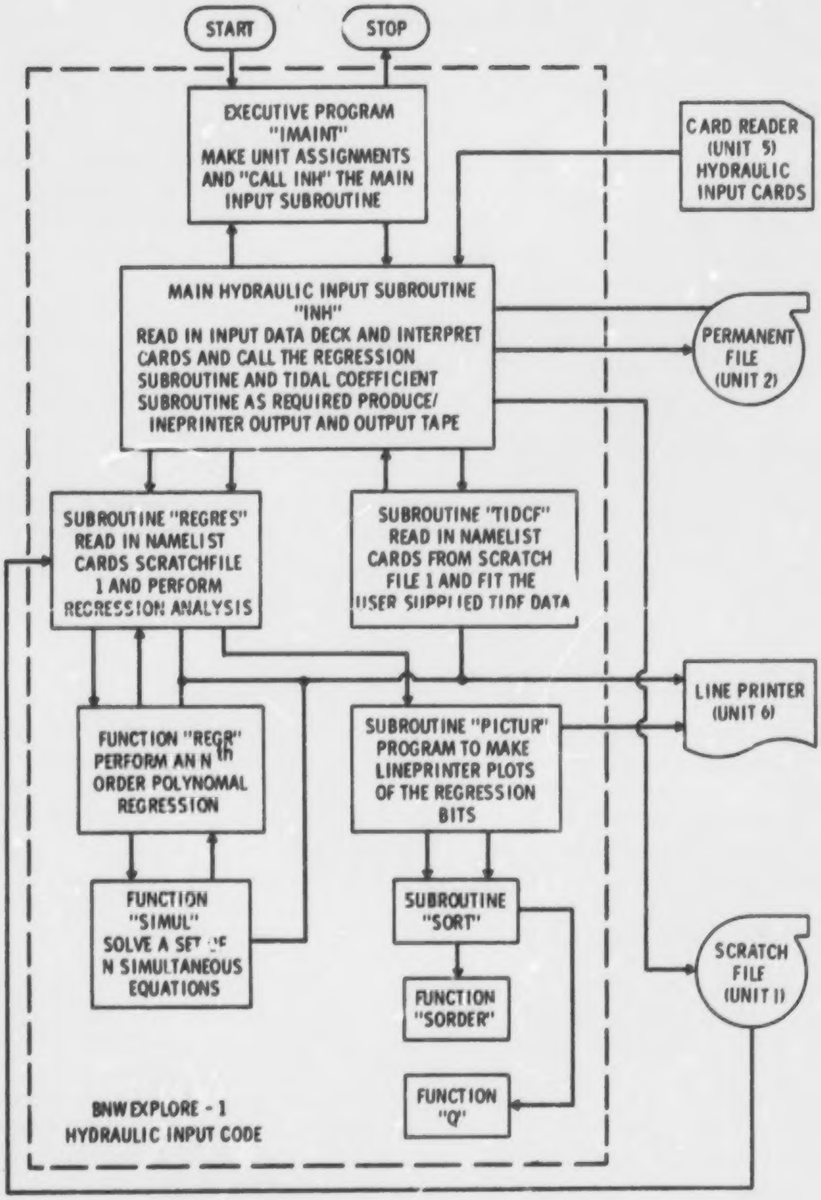
START
STOP
EXECUTIVE PROGRAM "IMAINT" MAKE UNIT ASSIGNMENTS AND "CALL INH" THE MAIN INPUT SUBROUTINE
CARD READER (UNIT 5) HYDRAULIC INPUT CARDS
MAIN HYDRAULIC INPUT SUBROUTINE "INH" READ IN INPUT DATA DECK AND INTERPRET CARDS AND CALL THE REGRESSION SUBROUTINE AND TIDAL COEFFICIENT SUBROUTINE AS REQUIRED PRODUCE/ INEPRINTER OUTPUT AND OUTPUT TAPE
PERMANENT FILE (UNIT 2)
SUBROUTINE "REGRES" READ IN NAMELIST CARDS SCRATCHFILE 1 AND PERFORM REGRESSION ANALYSIS
SUBROUTINE "TIDCF" READ IN NAMELIST CARDS FROM SCRATCH FILE 1 AND FIT THE USER SUPPLIED TIDE DATA
LINE PRINTER (UNIT 6)
FUNCTION "REGR" PERFORM AN Nth ORDER POLYNOMAL REGRESSION
SUBROUTINE "PICTUR" PROGRAM TO MAKE LINEPRINTER PLOTS OF THE REGRESSION BITS
FUNCTION "SIMUL" SOLVE A SET OF N SIMULTANEOUS EQUATIONS
SUBROUTINE "SORT"
FUNCTION "SORDER"
SCRATCH FILE (UNIT 1)
FUNCTION "Q"
BNW EXPLORE - 1 HYDRAULIC INPUT CODE

FIGURE C-1. RELATIONSHIP OF THE HYDRAULIC INPUT CALCULATION AND OUTPUT CODES

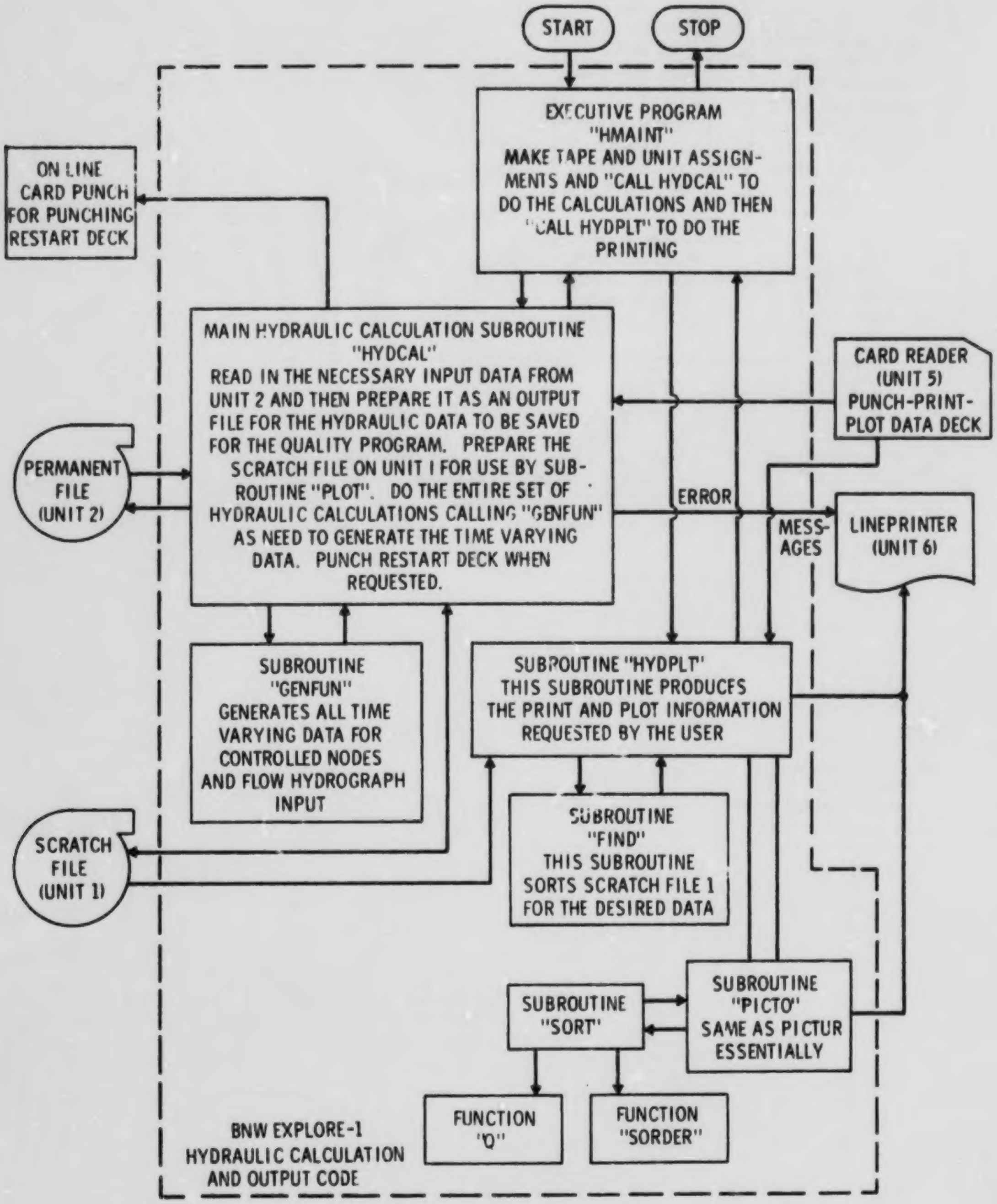
START
STOP
EXECUTIVE PROGRAM "HMAINT" MAKE TAPE AND UNIT ASSIGNMENTS AND "CALL HYDCAL" TO DO THE CALCULATIONS AND THEN "CALL HYDPLT" TO DO THE PRINTING
ON LINE CARD PUNCH FOR PUNCHING RESTART DECK
MAIN HYDRAULIC CALCULATION SUBROUTINE "HYDCAL" READ IN THE NECESSARY INPUT DATA FROM UNIT 2 AND THEN PREPARE IT AS AN OUTPUT FILE FOR THE HYDRAULIC DATA TO BE SAVED FOR THE QUALITY PROGRAM. PREPARE THE SCRATCH FILE ON UNIT I FOR USE BY SUBROUTINE "PLOT". DO THE ENTIRE SET OF HYDRAULIC CALCULATIONS CALLING "GENFUN" AS NEED TO GENERATE THE TIME VARYING DATA. PUNCH RESTART DECK WHEN REQUESTED.
CARD READER (UNIT 5) PUNCH-PRINT-PLOT DATA DECK
PERMANENT FILE (UNIT 2)
ERROR
MESSAGES
LINEPRINTER (UNIT 6)
SUBROUTINE "GENFUN" GENERATES ALL TIME VARYING DATA FOR CONTROLLED NODES AND FLOW HYDROGRAPH INPUT
SUBROUTINE "HYDPLT" THIS SUBROUTINE PRODUCES THE PRINT AND PLOT INFORMATION REQUESTED BY THE USER
SCRATCH FILE (UNIT 1)
SUBROUTINE "FIND" THIS SUBROUTINE SORTS SCRATCH FILE 1 FOR THE DESIRED DATA
SUBROUTINE "SORT"
SUBROUTINE "PICTO" SAME AS PICTUR ESSENTIALLY
FUNCTION "Q"
FUNCTION "SORDER"
BNW EXPLORE-1 HYDRAULIC CALCULATION AND OUTPUT CODE

FIGURE C-1. (CONTINUED)

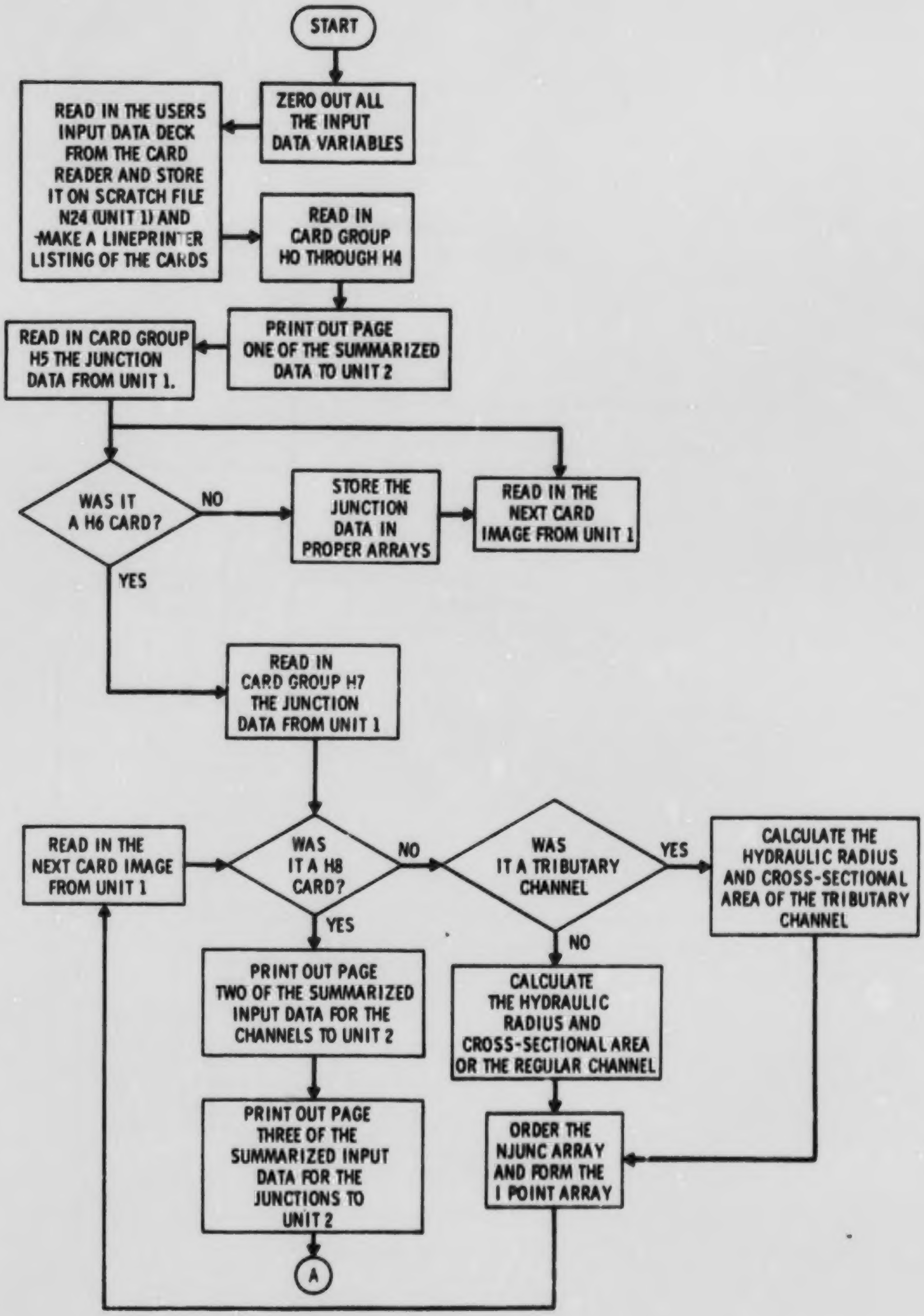
START
ZERO OUT ALL THE INPUT DATA VARIABLES
READ IN THE USERS INPUT DATA DECK FROM THE CARD READER AND STORE IT ON SCRATCH FILE N24 (UNIT 1) AND MAKE A LINEPRINTER LISTING OF THE CARDS
READ IN CARD GROUP H0 THROUGH H4
PRINT OUT PAGE ONE OF THE SUMMARIZED DATA TO UNIT 2
READ IN CARD GROUP H5 THE JUNCTION DATA FROM UNIT 1.
WAS IT A H6 CARD?
NO
STORE THE JUNCTION DATA IN PROPER ARRAYS
READ IN THE NEXT CARD IMAGE FROM UNIT 1
YES
READ IN CARD GROUP H7 THE JUNCTION DATA FROM UNIT 1
READ IN THE NEXT CARD IMAGE FROM UNIT 1
WAS IT A H8 CARD?
NO
WAS IT A TRIBUTARY CHANNEL
YES
CALCULATE THE HYDRAULIC RADIUS AND CROSS-SECTIONAL AREA OF THE TRIBUTARY CHANNEL
YES
PRINT OUT PAGE TWO OF THE SUMMARIZED INPUT DATA FOR THE CHANNELS TO UNIT 2
NO
CALCULATE THE HYDRAULIC RADIUS AND CROSS-SECTIONAL AREA OR THE REGULAR CHANNEL
PRINT OUT PAGE THREE OF THE SUMMARIZED INPUT DATA FOR THE JUNCTIONS TO UNIT 2
ORDER THE NJUNC ARRAY AND FORM THE I POINT ARRAY
A

FIGURE C-2. FLOW CHART OF SUBROUTINE INH

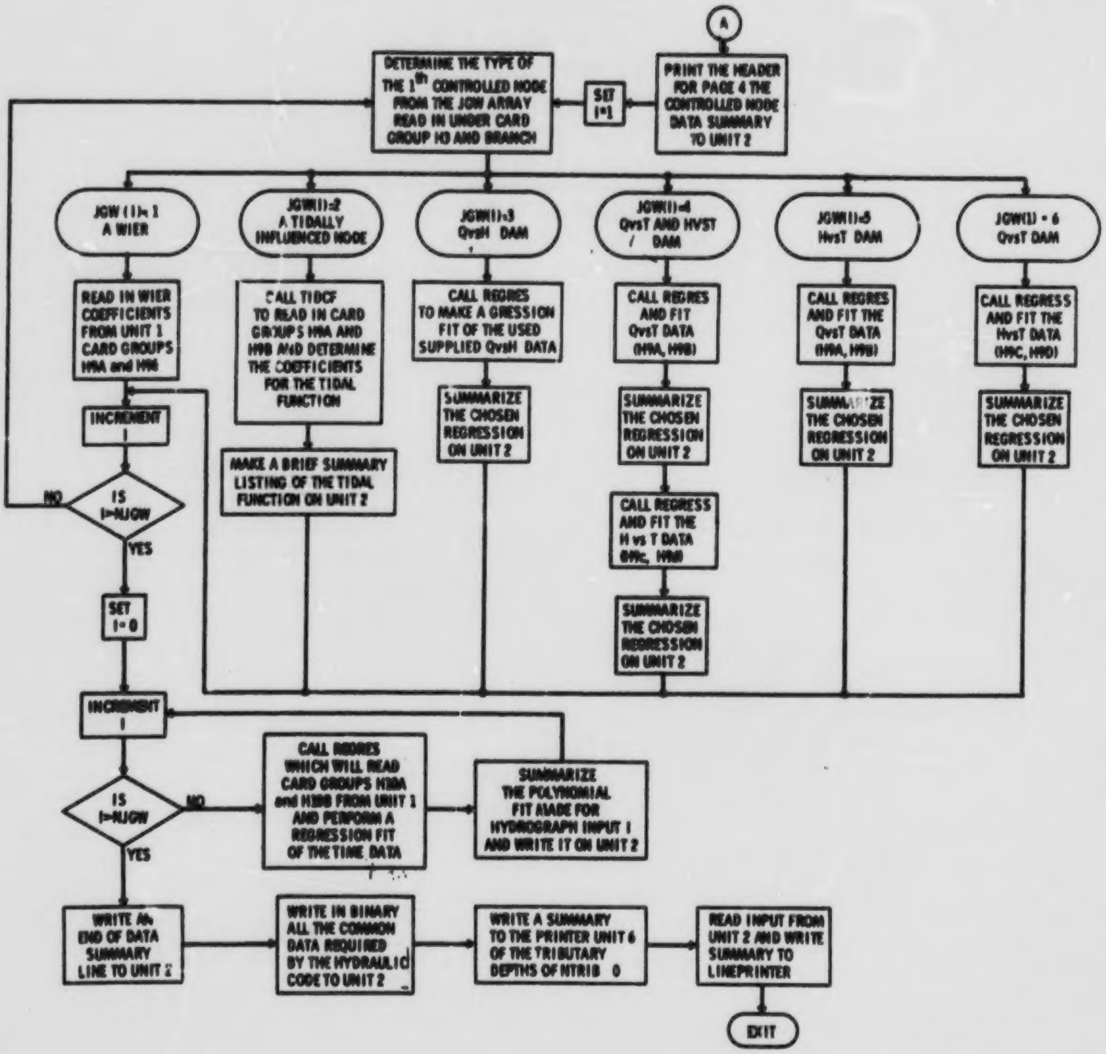
A
PRINT THE HEADER FOR PAGE 4 THE CONTROLLED NODE DATA SUMMARY TO UNIT 2
SET I=1
DETERMINE THE TYPE OF THE Ith CONTROLLED NODE FROM THE JGW ARRAY READ IN UNDER CARD GROUP H3 AND BRANCH
JGW (I)= 1 A WIER
JGW(I)=2 A TIDALLY INFLUENCED NODE
JGW(I)=3 QvsH DAM
JGW(I)=4 QvsT AND HVST / DAM
JGW(I)=5 HvsT DAM
JGW(I) = 6 QvsT DAM
READ IN WIER COEFFICIENTS FROM UNIT 1 CARD GROUPS H9A and H9B
CALL TIDCF TO READ IN CARD GROUPS H9A AND H9B AND DETERMINE THE COEFFICIENTS FOR THE TIDAL FUNCTION
CALL REGRES TO MAKE A GRESSION FIT OF THE USED SUPPLIED QvsH DATA
CALL REGRES AND FIT QvsT DATA (H9A, H9B)
CALL REGRES AND FIT THE QvsT DATA (H9A, H9B)
CALL REGRESS AND FIT THE HvsT DATA (H9C, H9D)
MAKE A BRIEF SUMMARY LISTING OF THE TIDAL FUNCTION ON UNIT 2
SUMMARIZE THE CHOSEN REGRESSION ON UNIT 2
SUMMARIZE THE CHOSEN REGRESSION ON UNIT 2
CALL REGRESS AND FIT THE H vs T DATA (H9C, H9D)
SUMMARIZE THE CHOSEN REGRESSION ON UNIT 2
SUMMARIZE THE CHOSEN REGRESSION ON UNIT 2
SUMMARIZE THE CHOSEN REGRESSION ON UNIT 2
INCREMENT I
IS I>NJGW
NO
YES
SET I= 0
INCREMENT I
IS I>NJGW
NO
YES
CALL REGRES WHICH WILL READ CARD GROUPS H10A and H10B FROM UNIT 1 AND PERFORM A REGRESSION FIT OF THE TIME DATA
SUMMARIZE THE POLYNOMIAL FIT MADE FOR HYDROGRAPH INPUT I AND WRITE IT ON UNIT 2
WRITE AN END OF DATA SUMMARY LINE TO UNIT 2
WRITE IN BINARY ALL THE COMMON DATA REQUIRED BY THE HYDRAULIC CODE TO UNIT 2
WRITE A SUMMARY TO THE PRINTER UNIT 6 OF THE TRIBUTARY DEPTHS OF NTRIB 0
READ INPUT FROM UNIT 2 AND WRITE SUMMARY TO LINEPRINTER
EXIT

FIGURE C-2. (CONTINUED)

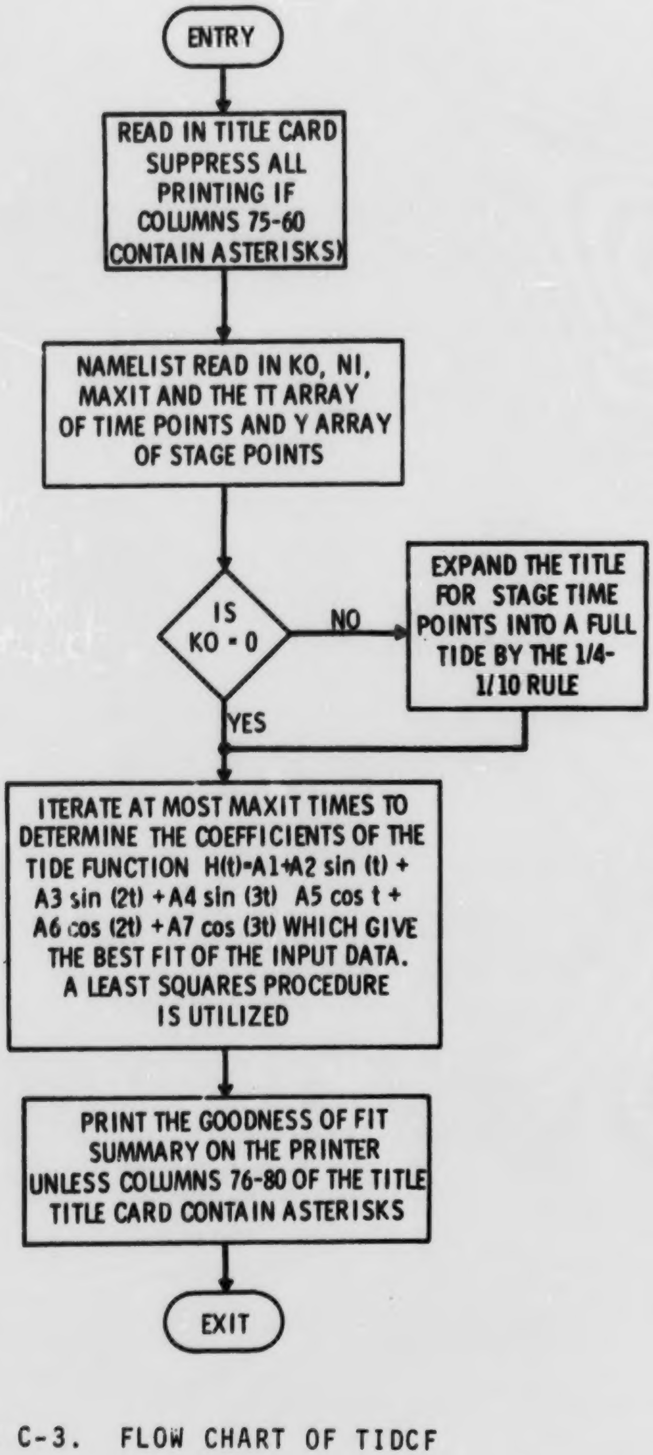
ENTRY
READ IN TITLE CARD SUPPRESS ALL PRINTING IF COLUMNS 75-60 CONTAIN ASTERISKS)
NAMELIST READ IN KO, NI, MAXIT AND THE TT ARRAY OF TIME POINTS AND Y ARRAY OF STAGE POINTS
IS KO = 0
NO
EXPAND THE TITLE FOR STAGE TIME POINTS INTO A FULL TIDE BY THE 1/4-1/10 RULE
YES
ITERATE AT MOST MAXIT TIMES TO DETERMINE THE COEFFICIENTS OF THE TIDE FUNCTION H(t)=A1+A2 sin (t) + A3 sin (2t) + A4 sin (3t) A5 cos t + A6 cos (2t) + A7 cos (3t) WHICH GIVE THE BEST FIT OF THE INPUT DATA. A LEAST SQUARES PROCEDURE IS UTILIZED
PRINT THE GOODNESS OF FIT SUMMARY ON THE PRINTER UNLESS COLUMNS 76-80 OF THE TITLE TITLE CARD CONTAIN ASTERISKS
EXIT

FIGURE C-3. FLOW CHART OF TIDCF

Subroutine PICTUR prepares a lineprinter plot of a set of N data points. Figure C-4 shows a flow chart of PICTUR. This subroutine uses subroutine SORT and functions SORDER and Q to sort the plot points according to descending values of y.

Hydraulic Calculations Program

Executive Program HMAINT serves only to make I/O device assignments and to call the calculation subroutine HYDCAL and the print-plot program HYDPLT.

Subroutine HYDCAL, the hydraulic calculation program, receives its input data from tape unit 2 and carries out the hydraulic computations. HYDCAL calls subroutine GENFUN as required to generate all time varying input functions and to solve the Wier formula. Figure C-5 shows a flow diagram of HYDCAL.

Subroutine GENFUN, a flow diagram of which is shown in Figure C-6, is used to solve the weir formula and to generate the functional values of all input variables which were fit via polynomial regression.

Subroutine HYDPLT is used to print out the hydraulic information calculated by HYDCAL for the user-requested sets of junctions and channels. Figure C-7 is a flow diagram of subroutine HYDPLT. The plotting program PICTO used by HYDPLT is identical to PICTUR, except that titles are printed on the plots and a check insures that the data plotted covers 75 percent or more of the X axis.

The variables used in the hydraulic program and their definitions are given in Table C-1. Figure C-8 is a listing of the input code and Figure C-9 is a listing of the calculational code.

RIVER BASIN QUALITY CODE

The quality code consists of two separate executable programs, an input code and a calculational code, which must be executed in sequence. Figure C-10 shows the relationship of the two programs.

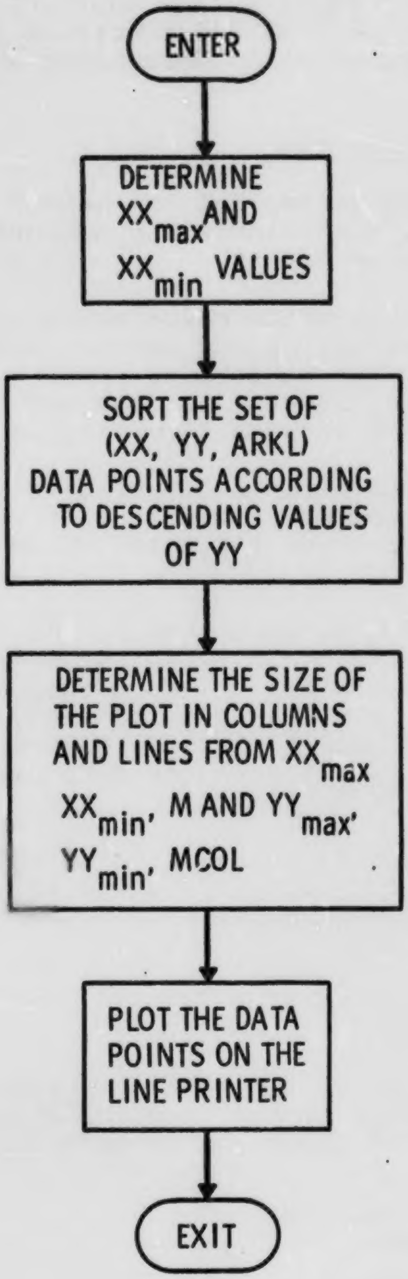
ENTER
DETERMINE XX_{max} AND XX_{min} VALUES
SORT THE SET OF (XX, YY, ARKL) DATA POINTS ACCORDING TO DESCENDING VALUES OF YY
DETERMINE THE SIZE OF THE PLOT IN COLUMNS AND LINES FROM XX_{max} XX_{min}, M AND YY_{max}, YY_{min}, MCOL
PLOT THE DATA POINTS ON THE LINE PRINTER
EXIT

FIGURE C-4. FLOW CHART OF SUBROUTINE PICTUR

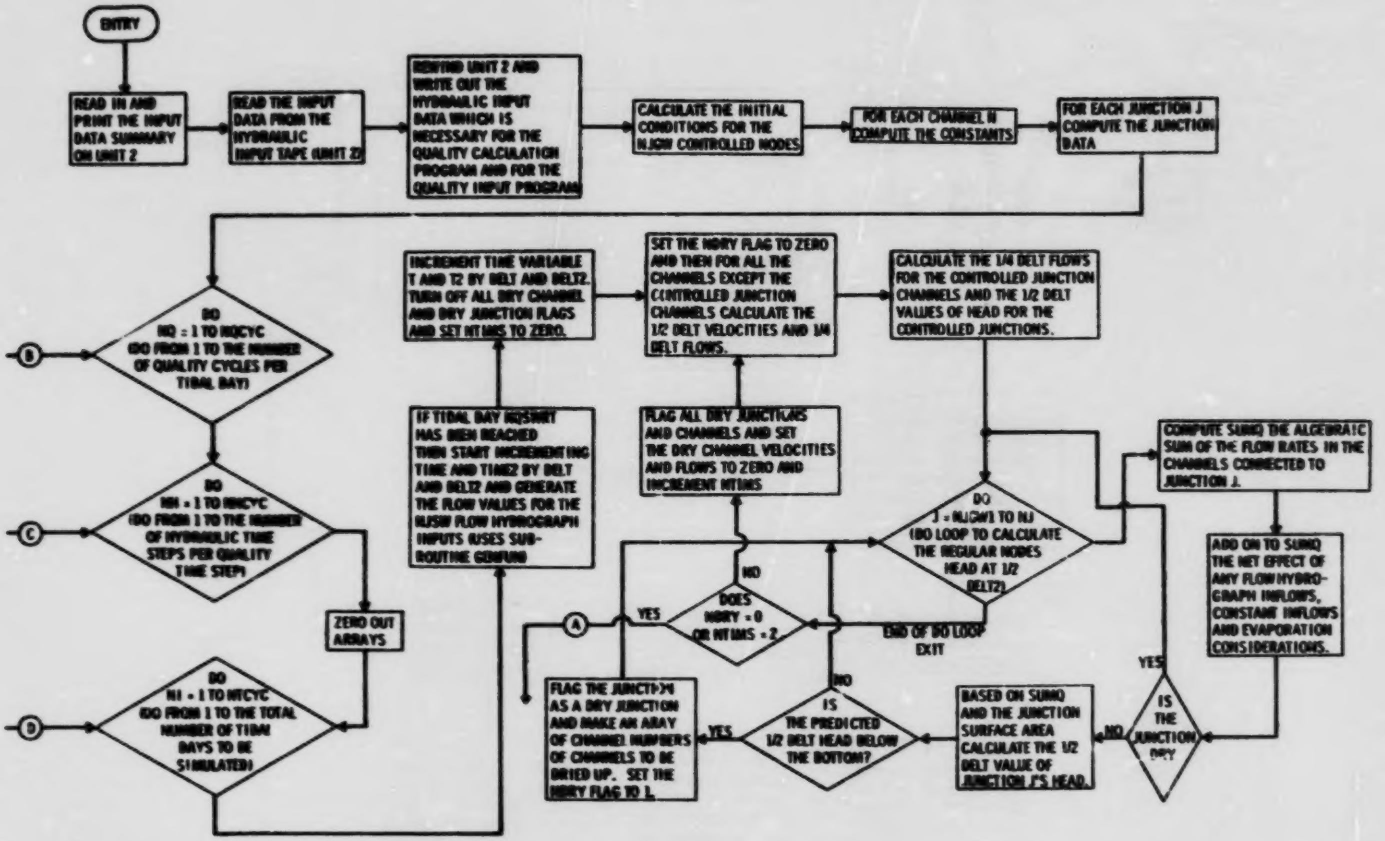
ENTRY
READ IN AND PRINT THE INPUT DATA SUMMARY ON UNIT 2
READ THE INPUT DATA FROM THE HYDRAULIC INPUT TAPE (UNIT 2)
REWIND UNIT 2 AND WRITE OUT THE HYDRAULIC INPUT DATA WHICH IS NECESSARY FOR THE QUALITY CALCULATION PROGRAM AND FOR THE QUALITY INPUT PROGRAM
CALCULATE THE INITIAL CONDITIONS FOR THE NJGW CONTROLLED NODES
FOR EACH CHANNEL N COMPUTE THE CONSTANTS
FOR EACH JUNCTION J COMPUTE THE JUNCTION DATA
B
DO NQ = 1 TO NQCYC (DO FROM 1 TO THE NUMBER OF QUALITY CYCLES PER TIDAL DAY)
C
DO NH = 1 TO NHCYC (DO FROM 1 TO THE NUMBER OF HYDRAULIC TIME STEPS PER QUALITY TIME STEP)
ZERO OUT ARRAYS
D
DO NI = 1 TO NTCYC (DO FROM 1 TO THE TOTAL NUMBER OF TIDAL DAYS TO BE SIMULATED)
IF TIDAL DAY NQSWRT HAS BEEN REACHED THEN START INCREMENTING TIME AND TIME2 BY DELT AND DELT2 AND GENERATE THE FLOW VALUES FOR THE NJSW FLOW HYDROGRAPH INPUTS (USES SUBROUTINE GENFUN)
INCREMENT TIME VARIABLE T AND T2 BY DELT AND DELT2. TURN OFF ALL DRY CHANNEL AND DRY JUNCTION FLAGS AND SET NTIMS TO ZERO.
SET THE NDRY FLAG TO ZERO AND THEN FOR ALL THE CHANNELS EXCEPT THE CONTROLLED JUNCTION CHANNELS CALCULATE THE 1/2 DELT VELOCITIES AND 1/4 DELT FLOWS.
CALCULATE THE 1/4 DELT FLOWS FOR THE CONTROLLED JUNCTION CHANNELS AND THE 1/2 DELT VALUES OF HEAD FOR THE CONTROLLED JUNCTIONS.
FLAG ALL DRY JUNCTIONS AND CHANNELS AND SET THE DRY CHANNEL VELOCITIES AND FLOWS TO ZERO AND INCREMENT NTIMS
NO
DOES NDRY = 0 OR NTIMS = 2
YES
A
DO J = NJGW1 TO NJ (DO LOOP TO CALCULATE THE REGULAR NODES HEAD AT 1/2 DELT2)
END OF DO LOOP EXIT
COMPUTE SUMQ THE ALGEBRAIC SUM OF THE FLOW RATES IN THE CHANNELS CONNECTED TO JUNCTION J.
ADD ON TO SUMQ THE NET EFFECT OF ANY FLOW HYDROGRAPH INFLOWS, CONSTANT INFLOWS AND EVAPORATION CONSIDERATIONS.
IS THE JUNCTION DRY
YES
NO
BASED ON SUMQ AND THE JUNCTION SURFACE AREA CALCULATE THE 1/2 DELT VALUE OF JUNCTION J'S HEAD.
IS THE PREDICTED 1/2 DELT HEAD BELOW THE BOTTOM?
NO
YES
FLAG THE JUNCTION AS A DRY JUNCTION AND MAKE AN ARAY OF CHANNEL NUMBERS OF CHANNELS TO BE DRIED UP. SET THE NDRY FLAG TO 1.

FIGURE C-5. FLOW CHART OF SUBROUTINE HYDCAL

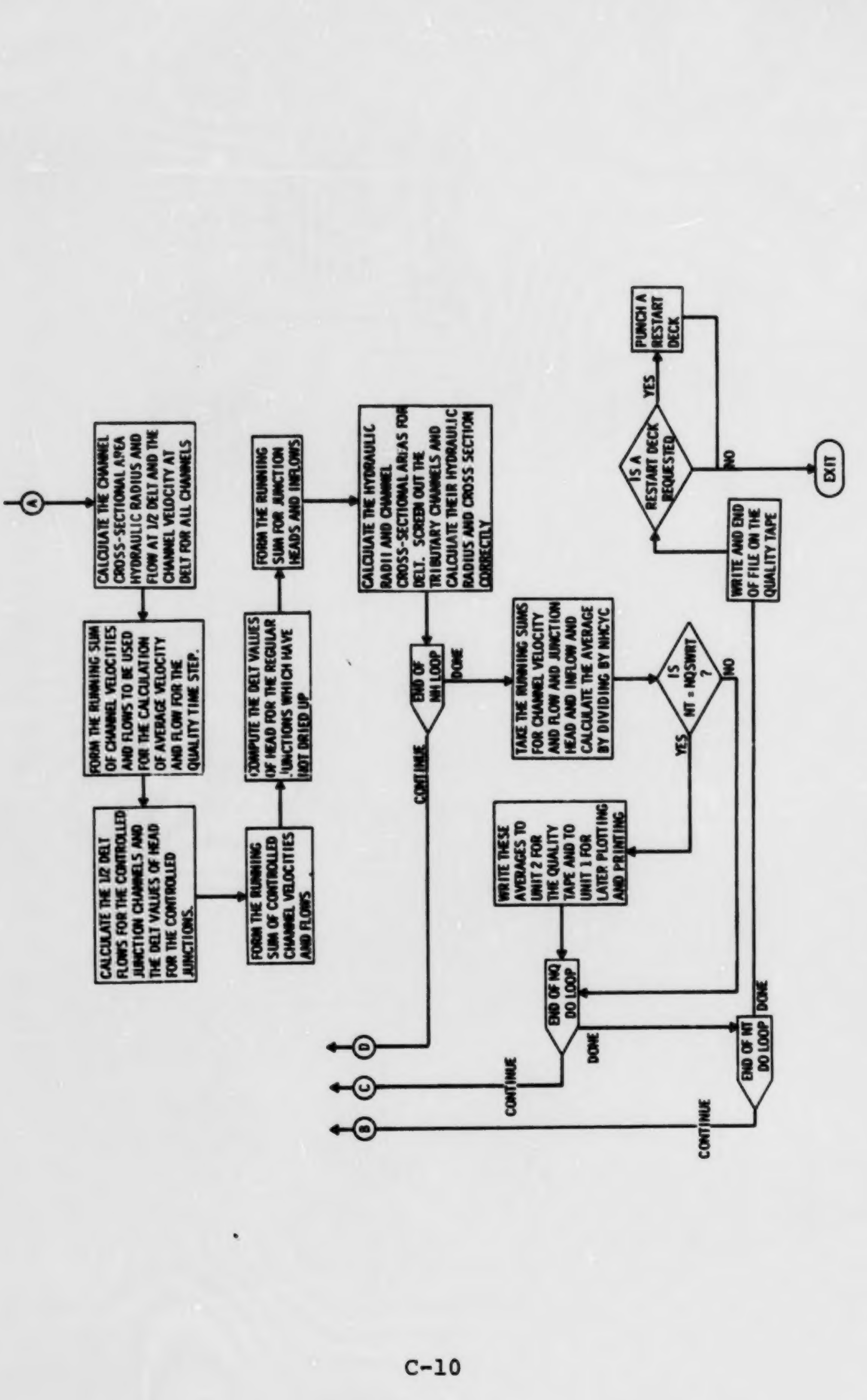
A
CALCULATE THE CHANNEL CROSS-SECTIONAL AREA HYDRAULIC RADIUS AND FLOW AT 1/2 DELT AND THE CHANNEL VELOCITY AT DELT FOR ALL CHANNELS
FORM THE RUNNING SUM OF CHANNEL VELOCITIES AND FLOWS TO BE USED FOR THE CALCULATION OF AVERAGE VELOCITY AND FLOW FOR THE QUALITY TIME STEP.
CALCULATE THE 1/2 DELT FLOWS FOR THE CONTROLLED JUNCTION CHANNELS AND THE DELT VALUES OF HEAD FOR THE CONTROLLED JUNCTIONS.
FORM THE RUNNING SUM OF CONTROLLED CHANNEL VELOCITIES AND FLOWS
COMPUTE THE DELT VALUES OF HEAD FOR THE REGULAR JUNCTIONS WHICH HAVE NOT DRIED UP
FORM THE RUNNING SUM FOR JUNCTION HEADS AND INFLOWS
CALCULATE THE HYDRAULIC RADII AND CHANNEL CROSS-SECTIONAL AREAS FOR DELT. SCREEN OUT THE TRIBUTARY CHANNELS AND CALCULATE THEIR HYDRAULIC RADIUS AND CROSS SECTION CORRECTLY
END OF NH LOOP
CONTINUE
DONE
D
TAKE THE RUNNING SUMS FOR CHANNEL VELOCITY AND FLOW AND JUNCTION HEAD AND INFLOW AND CALCULATE THE AVERAGE BY DIVIDING BY NHCYC
IS NT = NQSWRT ?
YES
NO
WRITE THESE AVERAGES TO UNIT 2 FOR THE QUALITY TAPE AND TO UNIT 1 FOR LATER PLOTTING AND PRINTING
END OF NQ DO LOOP
CONTINUE
DONE
C
END OF NT DO LOOP
CONTINUE
DONE
B
WRITE AND END OF FILE ON THE QUALITY TAPE
IS A RESTART DECK REQUESTED
YES
NO
PUNCH A RESTART DECK
EXIT

FIGURE C-5. (CONTINUED)

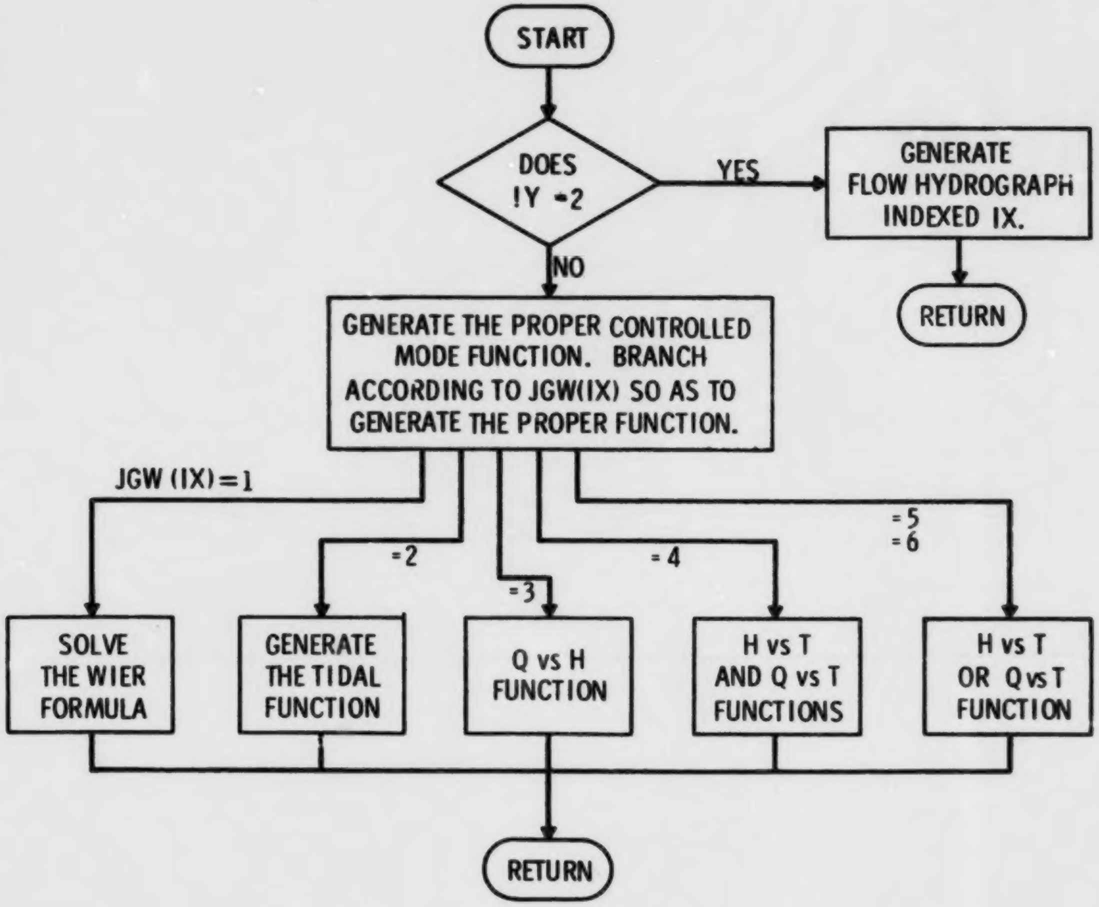
START
DOES !Y =2
YES
GENERATE FLOW HYDROGRAPH INDEXED IX.
RETURN
NO
GENERATE THE PROPER CONTROLLED MODE FUNCTION. BRANCH ACCORDING TO JGW(IX) SO AS TO GENERATE THE PROPER FUNCTION.
JGW (IX)=1
=2
=3
=4
=5
=6
SOLVE THE WIER FORMULA
GENERATE THE TIDAL FUNCTION
Q vs H FUNCTION
H vs T AND Q vs T FUNCTIONS
H vs T OR Q vs T FUNCTION
RETURN

FIGURE C-6. FLOW DIAGRAM OF SUBROUTINE GENFUN

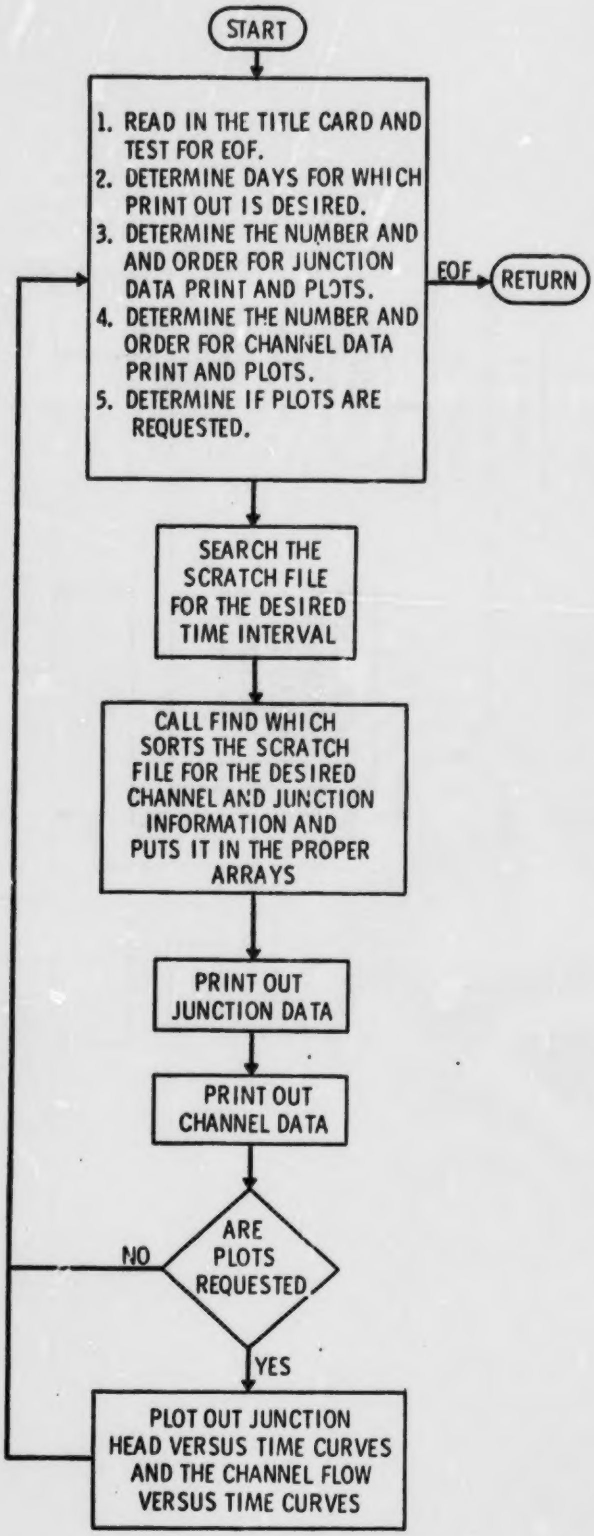
START
1. READ IN THE TITLE CARD AND TEST FOR EOF.
2. DETERMINE DAYS FOR WHICH PRINT OUT IS DESIRED.
3. DETERMINE THE NUMBER AND AND ORDER FOR JUNCTION DATA PRINT AND PLOTS.
4. DETERMINE THE NUMBER AND ORDER FOR CHANNEL DATA PRINT AND PLOTS.
5. DETERMINE IF PLOTS ARE REQUESTED.
EOF
RETURN
SEARCH THE SCRATCH FILE FOR THE DESIRED TIME INTERVAL
CALL FIND WHICH SORTS THE SCRATCH FILE FOR THE DESIRED CHANNEL AND JUNCTION INFORMATION AND PUTS IT IN THE PROPER ARRAYS
PRINT OUT JUNCTION DATA
PRINT OUT CHANNEL DATA
ARE PLOTS REQUESTED
NO
YES
PLOT OUT JUNCTION HEAD VERSUS TIME CURVES AND THE CHANNEL FLOW VERSUS TIME CURVES

FIGURE C-7. FLOW DIAGRAM OF SUBROUTINE HYDPLT

FIGURE C-8. LISTING OF THE HYDRAULIC INPUT COMPUTER PROGRAM FOR EXPLORE-I

```
C     **************  MAIN PROGRAM FOR EXPLORE-1 INPUT     *************
C     ************** BATTELLE NORTHWEST 11/9/71             *************
C     ****************************************************************
C
C
C     ************** ASSIGN THE COMMON  DATA                *************
      COMMON /TAPES/N5,N6,N20,N22,N24
      COMMON/PARAMS/IZ5,IZ6,IZ9,IZ12,IZ13
C
C     ************** CONTROL AND TITLE INFORMATION          *************
      COMMON /PTINT/ NT,NC,NJGW,NTCYC,NQSWRT,NQCYC,DELTQ,PERIOD,
     1ALPHA(30),DEP(500),IPOINT(500,6),AS(500),EVAP
      COMMON/QUAL/NCHAN(500,6),LEN(600),NJUNC(600,2),JGW(29)
C
      REAL LEN
C
C     *************  ASSIGN THE UNIT NUMBERS AND REWIND    *************
C
      IZ5=500
      IZ6=6
      IZ9=600
      IZ12=20
      IZ13=20
      N5=5
      N6=6
      N20=2
      N24=1
      REWIND N20
      REWIND N24
C     **************               END                    *************
C
C     **************   HYDRAULIC INPUT                    *************
      CALL INH
      REWIND N24
      REWIND N20
C     **************               END                    *************
      STOP
      END
      SUBROUTINE INH
C     ************** INPUT PROGRAM FOR EXPLORE-1          *************
C
C     ************** BATTELLF NORTHWEST 11/9/71           *************
C     *****************************************************************
C
C
C     ************** ASSIGN THE COMMON  DATA              *************
      COMMON /TAPES/N5,N6,N20,N22,N24
      COMMON/PARAMS/IZ5,IZ6,IZ9,IZ12,IZ13
C
C     ************** CONTROL AND TITLE INFORMATION        *************
      COMMON /P(INT/ NJ,NC,NJGW,NTCYC,NQSWRT,NQCYC,DELTQ,PERIOD,
     1ALPHA(30),DEP(500),IPOINT(500,6),AS(500),EVAP
      COMMON/QUAL/NCHAN(500,6),LEN(600),NJUNC(600,2),JGW(20)
      COMMON QINT,DELT,WIND,WDIR,NJSW,NHCYC,NT,ICYC,NCYC,W,
     1NEXIT,JSW(20),A0(3,20,10)
C
C     ************** JUNCTION INFORMATION                 *************
C
      COMMON H(500),VOL(500),X(500),Y(500),
     1QIN(500),QOU(500),QINST(20)
C
C     ************** CHANNEL INFORMATION                  *************
C
      COMMON B(600),R(600),A(600),AK(600),Q(600),V(600),
     1FWIND(600),NTEMP(6),NCLOS(600)
      COMMON HYDRAD(600)
      COMMON ITRIB(50,2),TRBDEP(50),NTRIB
C
      REAL LEN
      DIMENSION ARRAY(33),ATEMP(10)
      DATA ASTERK,BLANK/4H****,4H
C     **************                END                   *************
C     *****************************************************************
C
C     ************** ZERO ALL THE INPUT DATA VARIABLES    *************
      NTCYC=0
      PERIOD=0.
      QINT-0.
      DELT=0.
      WIND=0.
      WDIR=0.
      NQSWRT=0
      NJSW=0
      NJGW=0
      NQCYC=0
      NHCYC=0
      NT=0
      DELTQ=0.
      ICYC=0
      NCYC=0
      NEXIT=0
      NJ=0
      NC=0
      NTRIB=0
      DO 100 I=1,50
      TRBDEP(I)=0.
      ITRIB(I,1)=0
100   ITRIB(I,2)=0
      DO 120 L=1,IZ12
      DO 110 II=1,10
      AO(1,L,II)=0.
      AO(2,L,II)=0
110   AO(3,L,II)=0.
      QINST(L)=0.
120   JSN(L)=0
      DO 130 I=1,IZ13
130   JCN(I)=0
      DO 140 I=1,30
140   ALPHA(I)=BLANK
      DO 160 J=1,IZ5
      H(J)=0.
      AS(J)=0.
      VOL(J)=0.
      X(J)=0.
      Y(J)=0.
      DEP(J)=0.
      QIN(J)=0.
      QOU(J)=0.
      DO 150 K=1,IZ6
      NTEMP(K)=0
      IPOINT(J,K)=0
150   NCHAN(J,K)=0
160   CONTINUE
      DO 170 I=1,IZ9
      LEN(I)=0.
      NJUNC(I,1)=0
      NJUNC(I,2)=0
      B(I)=0.
      R(I)=0.
      A(I)=0.
      AK(I)=0.
      Q(I)=0.
      V(I)=0.
      FWIND(I)=0.
      NCLOS(I)=0
170   CONTINUE
C
C     ***************             END                 ***************
C     ******************************************************************
C     *************** START OF THE INPUT PROGRAM      ***************
C     ******************************************************************
```

```
      NCYC=0
      NEXIT=0
      NJ=0
      NC=0
      NTRIB=0
      DO 100 I=1,50
      TRBDEP(I)=0.
      ITRIB(I,1)=0
  100 ITRIB(I,2)=0
      DO 120 L=1,IZ12
      DO 110 II=1,10
      AO(1,L,II)=0.
      AO(2,L,II)=0.
  110 AO(3,L,II)=0.
      QINST(L)=0.
  120 JSW(L)=0
      DO 130 I=1,IZ13
  130 JGW(I)=0
      DO 140 I=1,30
  140 ALPHA(I)=BLANK
      DO 160 J=1,IZ5
      H(J)=0.
      AS(J)=0.
      VOL(J)=0.
      X(J)=0.
      Y(J)=0.
      DEP(J)=0.
      QIN(J)=0
      QOU(J)=0
      DO 150 K=1,IZ6
      NTEMP(K)=0
      IPOINT(J,K)=0
  150 NCHAN(J,K)=0
  160 CONTINUE
      DO 170 I=1,IZ9
      LEN(I)=0.
      NJUNC(I,1)=0
      NJUNC(I,2)=0
      B(I)=0.
      R(I)=0.
      A(I)=0.
      AK(I)=0.
      Q(I)=0.
      V(I)=0.
      FWIND(I)=0.
      NCLOS(I)=0
  170 CONTINUE
C
C     **************             END                         *************
C     ******************************************************************
C     ************** START OF THE INPUT PROGRAM            *************
C     ******************************************************************
```

```
C
      N7=N20
180   CONTINUE
      READ (N5,740) (ALPHA(I),I=1,20)
      WRITE (N6,750) (ALPHA(I),I=1,20)
      IF (ALPHA(1).EQ.ASTERK) GO TO 190
      WRITE (N24,740) (ALPHA(I),I=1,20)
      GO TO 180
190   CONTINUE
      WRITE (N6,760)
      END FILE N24
      REWIND N24
      N5=N24
C
C     ************** READ IN CARD GROUP H0                    *************
      READ (N5,770) ALPHA
C     **************             END                          *************
C
C     **************  READ IN CARD GROUP H1                   *************
      READ (N5,780) NTCYC,PERIOD,QINT,DELT,EVAP,WIND,WDIR,NOSHRT,N
     1JSW,NJGW,NTRIB
      IF (NTRIB.LE.50) GO TO 200
      WRITE (6,650) NTRIB
      STOP
200   CONTINUE
      IPERID=PERIOD+0.1
      IQINT=QINT*3600.+0.1
      IDELT=DELT+0.1
      NQCYC=(IPERID*3600)/IQINT
      NHCYC=IQINT/IDELT
      NINT=(IPERID*3600)/IDELT
      NPDEL=(NINT+50)/100
      DELTQ=DELT*FLOAT(NHCYC)
C     **************             END                          *************
C
C     ************** READ IN CARD GROUP H2                    *************
      IF (NJSW.LE.0) GO TO 210
      READ (N5,790) (JSW(L),L=1,NJSW)
210   CONTINUE
C     **************             END                          *************
C
C     ************** READ IN CARD GROUP H3                    *************
      READ (N5,790) (JGW(I),I=1,NJGW)
C     **************             END                          *************
C
C     ************** READ IN CARD GROUP H4                    *************
      IF (NTRIB.LE.0) GO TO 230
      DO 220 I=1,NTRIB
      READ (N5,660) ITRIB(I,1),ITRIB(I,2)
220   CONTINUE
230   CONTINUE
C     **************                     END                  *************
```

```
C
C     ************** PRINT OUT PAGE ONE  THE CONTROL DATA  *************
      WRITE (N7,800) ALPHA
      WRITE (N7,810) NTCYC
      WRITE (N7,820) NQCYC
      WRITE (N7,830) NHCYC
      WRITE (N7,840) DELT
      WRITE (N7,710) EVAP
      EVAP=EVAP/(12.*30.*86400.)
      WRITE (N7,860) WIND,WDIR
      WRITE (N7,870) NOSWRT
      IF (NTRIB.LT.0) GO TO 240
      WRITE (N7,670) NTRIB
      WRITE (N7,680) (ITRIB(I,1),ITRIB(I,2),I=1,NTRIB)
240   CONTINUE
C     *************             END                           *************
C
C     ******************************************************************
C     ************** READ  CARD GROUP H5                       *************
C     ************** READ IN THE JUNCTION INFORMATION          *************
C     ******************************************************************
      NJ=0
      DO 250 I=1,IZ5
      READ (N5,880) J,HEAD,SURF,QF1,QF2,DT,X1,Y1
      DT=-DT
C     ************** DID WE READ IN A CARD GROUP H6 CARD     *************
      IF (J.GT.IZ5) GO TO 260
      NJ=NJ+1
      IF (J.NE.NJ) WRITE (N6,720)
      H(J)=HEAD
      AS(J)=SURF
      QIN(J)=QF1
      QOU(J)=QF2
      X(J)=X1
      Y(J)=Y1
      DEP(J)=DT
250   CONTINUE
260   CONTINUE
      IF (NJSW.LE.0) GO TO 280
      DO 270 L=1,NJSW
      J=JSW(L)
270   QINST(L)=QIN(J)
280   CONTINUE
C     *************             END                           *************
C
C     ******************************************************************
C     ************** READ  CARD GROUP H7                       *************
C     ************** READ IN THE CHANNEL INFORMATION           *************
C     ******************************************************************
      NC=0
      DO 360 I=1,IZ9
      READ (N5,890) N,(NTEMP(K),K=1,2),ALEN,WIDTH,RAD,COEF,VEL
      RAD=-RAD
C     ************** DID WE READ IN A CARD GROUP H8 CARD   *************
      IF (N.GT.I29) GO TO 370
      NC=NC+1
      IF (N.NE.NC) WRITE (N6,900)
      N=NC
      LEN(N)=ALEN
      B(N)=WIDTH
      K=MAX0(NTEMP(1),NTEMP(2))
      HYDRAD(N)=RAD+H(K)
      IFLAG=0
      IF (NTRIB.LE.0) GO TO 310
      DO 290 IL=1,NTRIB
      IF (N.EQ.ITRIB(IL,1)) GO TO 300
290   CONTINUE
      GO TO 310
300   IFLAG=1
      IJN=ITRIB(IL,2)
      TRBDEP(IL)=RAD-(DEP(IJN)-RAD)
      HYDRAD(N)=H(IJN)+DEP(IJN)
310   CONTINUE
      A(N)=HYDRAD(N)*WIDTH
      R(N)=RAD
      AK(N)=COEF
      V(N)=VEL
      NJUNC(N,1)=MIN0(NTEMP(1),NTEMP(2))
      NJUNC(N,2)=MAX0(NTEMP(1),NTEMP(2))
      K=NJUNC(N,1)
      IF (K.EQ.0) GO TO 360
      J=NJUNC(N,2)
      IF (IFLAG.EQ.1) GO TO 320
      HYDRAD(N)=RAD+(H(J)+H(K))/2.0
      A(N)=HYDRAD(N)*WIDTH
320   CONTINUE
      DO 330 J=1,I26
      IF (IPOINT(K,J).EQ.NJUNC(N,2)) GO TO 350
      IF (IPOINT(K,J).EQ.0) GO TO 340
330   CONTINUE
340   IPOINT(K,J)=NJUNC(N,2)
      NCHAN(K,J)=NC
      GO TO 360
C     **************    THERE IS A REDUNDANT CHANNEL      *************
350   NC=NC-1
      WRITE (N6,730) N,M
      M=NCHAN(K,J)
      LEN(M)=ALEN
      B(M)=B(M)+WIDTH
      R(M)=RAD
      A(M)=HYDRAD(N)*B(M)
      HYDRAD(M)=HYDRAD(N)
      AK(M)=COEF
      V(M)=VEL
```

```
  360 CONTINUE
  370 CONTINUE
C     **************            END                 **************
C
C     ************** OUTPUT PAGE TWO THE CHANNEL INFORMATION ************
      WRITE (N7,800) ALPHA
      WRITE (N7,910)
      DO 460 N=1,NC
      IF (AK(N).LE.0.0) AK(N)=0.016
      IF (B(N).GT.0.) GO TO 400
      K=NJUNC(N,1)
      NJUNC(N,1)=0
      IDEL=0
      DO 390 J=1,IZ6
      IF (IPOINT(K,J).EQ.0) GO TO 390
      IF (IPOINT(K,J).NE.NJUNC(N,2)) GO TO 380
      WRITE (N7,920) N,K,NJUNC(N,2)
      NCHAN(K,J)=0
      IPOINT(K,J)=0
      NJUNC(N,2)=0
      GO TO 460
  380 CONTINUE
  390 CONTINUE
  400 CONTINUE
      K=NJUNC(N,2)
      DO 430 J=1,IZ6
      IF (IPOINT(K,J).EQ.NJUNC(N,1)) GO TO 410
      GO TO 420
  410 CONTINUE
      IF (NJUNC(N,1).NE.0) GO TO 450
  420 CONTINUE
      IF (IPOINT(K,J).EQ.0) GO TO 440
  430 CONTINUE
  440 CONTINUE
      IPOINT(K,J)=NJUNC(N,1)
      NCHAN(K,J)=N
  450 CONTINUE
      TF=1000.
      IF (R(N).GT.-2.) TF=0.75*LEN(N)/SQRT(32.2*(R(N)+2.))
      XMK=BLANK
      IF (TF.LT.DELT) XMK=ASTERK
      WRITE (N7,930) N,LEN(N),B(N),A(N),AK(N),V(N),HYDRAD(N),(NJUNC(N,K)
     1,K=1,2),TF,XMK
  460 CONTINUE
C     **************            END                 **************
C
C     ************** OUTPUT PAGE THREE JUNCTION INFORMATION**************
      WRITE (N7,800) ALPHA
      WRITE (N7,940)
      ATOT=0.
      DO 470 J=1,NJ
      ATOT=ATOT+AS(J)
      WRITE (N7,950) J,H(J),AS(J),QIN(J),QOU(J),(NCHAN(J,K),K=1,IZ6),X(J
     1),Y(J)
  470 CONTINUE
      WRITE (N7,960) ATOT
C     **************            END                         **************
C
C     ************** OUTPUT PAGE FOUR , CONTROL NODE INFORMATION *******
      WRITE (N7,800) ALPHA
      WRITE (N7,970) NJGW
      DO 580 J=1,NJGW
      DO 480 II=1,10
      A0(2,J,II)=0
  480 A0(1,J,II)=0.
      WRITE (N7,900) J
      IJK=JGN(J)
      GO TO (490,500,510,520,540,550), IJK
C
C     **************              WIER TYPE CONTROLLED NODE      **************
  490 READ (N5,990) (ARRAY(I),I=1,20),A0(1,J,1),A0(1,J,2),A0(1,J,3)
      WRITE (N6,1000) (ARRAY(I),I=1,20),A0(1,J,1),A0(1,J,2),A0(1,J,3)
      WRITE (N7,1010) A0(1,J,1),A0(1,J,2),A0(1,J,3)
      GO TO 580
C     **************            END                         **************
C
C     ************** A TIDALLY CONTROLLED NODE              **************
  500 CALL TIDCF (ATEMP)
      WRITE (N7,1020) (ATEMP(I),I=1,7)
      GO TO 560
C     **************            END                         **************
C
C     ************** DAM WHICH IS OPERATED VIA A Q VS H POLICY **********
  510 CALL REGRES (ATEMP)
      WRITE (N7,1030) ATEMP
      GO TO 560
C     **************            END                         **************
C
C     **************  DAM WHERE THE Q VS T AND H VS T CURVES ARE KNOWN**
  520 CALL REGRES (ATEMP)
      WRITE (N7,1040) ATEMP
      DO 530 I=1,10
  530 A0(2,J,I)=ATEMP(I)
C     ****************************************************************
      CALL REGRES (ATEMP)
      WRITE (N7,1050) ATEMP
      GO TO 560
C     **************            END                         **************
C
C     ************** DAM WHERE THE H VS T CURVE IS KNOWN    **************
  540 CALL REGRES (ATEMP)
      WRITE (N7,1060) ATEMP
      GO TO 560
C     **************            END                         **************
```

```
C
C     ************** DAM WHERE THE Q VS T CURVE IS KNOWN  *************
550   CALL REGRES (ATEMP)
      WRITE (N7,1070) ATEMP
C     **************               END                    *************
C
560   DO 570 I=1,10
570   A0(1,J,I)=ATEMP(I)
580   CONTINUE
C     *****************************************************************
C     **************               END                    *************
C     *****************************************************************
C
C
C     ************* OUTPUT PAGE FIVE ,HYDROGRAPH NODE INFORMATION *****
      IF (NJSW.LE.0) GO TO 610
      WRITE (N7,880) ALPHA
      WRITE (N7,1080) NJSW
      DO 600 L=1,NJSW
      J=JSW(L)
      WRITE (N7,1090) J
      CALL REGRES (ATEMP)
      WRITE (N7,1100) ATEMP
      DO 590 I=1,10
590   A0(3,L,I)=ATEMP(I)
600   CONTINUE
610   CONTINUE
C     **************               END                    *************
C
C     **************  PREPARE HYDRODYNAMIC INPUT TAPE     *************
      WRITE (N7,1110) ASTERK
      WRITE (N7) NTCYC,PERIOD,QINT,DELT,WIND,WDIR,NQSWRT,NJSW,NJGW
     1,(JSW(L),QINST(L),((A0(I,L,N),I=1,3),N=1,10),L=1,IZ12),(JGW(L),L=1
     2,IZ13),(ALPHA(I),I=1,30),NQCYC,NHCYC,NT,DELTQ,ICYC,NCYC,NEXIT,NJ,N
     3C,((NCHAN(I,II),IPOINT(I,II),II=1,IZ6),H(I),H(I),H(I),H(I),H(I),AS
     4(I),VOL(I),X(I),Y(I),DEP(I),QIN(I),QOU(I),QIN(I),QOU(I),I=1,NJ),((
     5NJUNC(N,L),L=1,2),LEN(N),B(N),R(N),A(N),A(N),AK(N),Q(N),Q(N),Q(N),
     6V(N),V(N),V(N),FWIND(N),NCLOS(N),N=1,NC),EVAP,NTRIB,(TRBDEP(I),ITR
     7IB(I,1),ITRIB(I,2),I=1,50)
      WRITE (6,690) NTRIB
      DO 620 I=1,NTRIB
      WRITE (6,700) ITRIB(I,1),ITRIB(I,2),TRBDEP(I)
620   CONTINUE
      END FILE N7
      REWIND N7
C     **************               END                    *************
C
C
C     ************** PRINT OUT THE HYDRONAMIC INPUT DATA   *************
      READ (N7)
630   READ (N7,1120) ARRAY
      IF (ARRAY(1).EQ.ASTERK) GO TO 640
      WRITE (N6,1120) ARRAY
      GO TO 630
640   WRITE (N6,1130)
      N5=5
C     **************            END                        *************
C
      RETURN
C
C
C     ************** FORMAT STATEMENT 950 MUST BE CHANGED  *************
C     ************** WHENEVER PARAMETER IZ6 IS CHANGED     *************
C
C
C
650    FORMAT (' YOU REQUESTED TOO MANY TRIBUTARIES'/,I5,' TO BE EXACT(JO
      1B ABORTED) '//)
660    FORMAT (2I5)
670    FORMAT (' THIS PROPLEM HAS ',I5,' TRIBUTARY CHANNFL(S).'/' THEY(IT
      1) ARE(I5)'/' CHANNEL NO.    CHARACTERISTIC'/15X,'JUNCTION NUMBER
      2 '//)
680    FORMAT (I10,10X,I5)
690    FORMAT (I5)
700    FORMAT (I5,5X,I5,5X,1PE12.5)
710    FORMAT (1H0,'THE EVAPORATION RATE IS ',1PE10.3,' (INCHES/MONTH)')
720    FORMAT (' THE JUNCTION INFORMATION IS OUT OF ORDER')
730    FORMAT ('CHANNELS',I5,' AND',I5,' ARE REDUNDANT')
740    FORMAT (20A4)
750    FORMAT (26X,20A4)
760    FORMAT (1H1)
770    FORMAT (15A4)
780    FORMAT (I5,3F5.0,5X,3F5.0,4I5)
790    FORMAT (20I5)
800    FORMAT (1H1,15A4,20X,20HBATTELLE NORTHWEST  ,/1X,15A4,19X,21H RICH
      1LAND, WASHINGTON,/,80X,20H HYDRODYNAMIC MODEL ,//)
810    FORMAT (15H0DAYS SIMULATED,I4)
820    FORMAT (29H0WATER QUALITY CYCLES PER DAY,I4)
830    FORMAT (43H0INTEGRATION CYCLES PER WATER QUALITY CYCLE,I4)
840    FORMAT (30H0LENGTH OF INTEGRATION STEP IS,F6.0,8H SECONDS)
860    FORMAT (15H0WIND VELOCITY,F5.0,22H MPH   WIND DIRECTION,F5.0,19H D
      1EGREES FROM NORTH)
870    FORMAT (26H0WRITE CYCLE STARTS AT THE,I4,11H TIME CYCLE//)
880    FORMAT (I5,F10.2,-6PF10.2,0P2F10.2,F10.2,5X,-3P2F10.3)
890    FORMAT (3I5,10X,5F10.0)
900    FORMAT (45H CHANNEL INPUT INFORMATION OUT OF ORDER      )
910    FORMAT (108H CHANNEL  LENGTH   WIDTH     AREA     MANNING  VELOCI
      1TY   HYD RADIUS             JUNCTIONS AT ENDS    MAX INT/67H  NUMBER
      2    (FT)      (FT)     (SQ FT)   COEF.       (FPS)         (FT)/,31X,'
      3X .001'/)
920    FORMAT (8H CHANNEL,I4,8H JOINING,I4,4H AND,I4,38H DELETED DUE TO Z
      1ERO OR NEGATIVE WIDTH)
930    FORMAT (I5,F11.0,F8.0,-3PF10.0,0PF9.3,F10.2,F13.1,I19,I6,F16.0,1X,,
      1A4)
```

```
940  FORMAT (124H JUNCTION    INITIAL HEAD   SURFACE AREA    INPUT    OU
    1TPUT              CHANNELS ENTERING JUNCTION                COORDIN
    2ATES/122H  NUMBER          (FT)        (10**6 SQ FT)   (CFS)     (CFS
    3)                                                          X       Y/
    4)
950  FORMAT (I7,F13.2,-6PF15.2,0P2F10.0,I10,5I6,12X,-3PF10.1,F7.1)
960  FORMAT (E20.6)
970  FORMAT (//,18H THIS PROBLEM HAS ,I5,20H CONTROLLED NODES   ,/)
980  FORMAT (16H0JUNCTION NUMBER,I5)
990  FORMAT (20A4,/3F10.0)
1000 FORMAT (1H1,20A4/30H THE INPUT WEIR CONSTANTS ARE /5H A1= ,E10.4,2
    1X,5H A2= ,E10.4,2X,5H A3= ,E10.4//)
1010 FORMAT (1H+,22X,10H IS A WEIR/34H THE CONTROLLING WEIR FORMULA IS
    1/,' DELH=DELT/AREA*(INFLOW-A1*(HEAD-A2+DELH/2)**A3)'/,' WHERE A1 =
    2 ',E12.5,8H ,A2 =  ,E12.5,8H ,A3 =  ,E12.5)
1020 FORMAT (1H+,22X,30H IS A TIDALLY INFLUENCED NODE /50H THE PERIODIC
    1 STAGE-TIME HISTORY IS GIVEN BY      /105H H(T)=A1+A2*SIN(W*T)+A3*
    2SIN(2*W*T)+A4*SIN(3*W*T)+A5*COS(W*T)+A6*COS(2*W*T)+A7*COS(3*W*T)
    3                /11H WHERE A1= ,E10.4,6H , A2=,E10.4,6H, A3= ,E10.4
    4,6H, A4= ,E10.4,6H, A5= ,E10.4,6H, A6= ,E10.4,6H, A7= ,E10.4)
1030 FORMAT (1H+,22X,55H IS A DAM WHICH IS OPERATED ACCORDING TO A Q VS
    1 H CURVE/62H THE CONTROLLING Q VS H CURVE IS FIT BY THE FOLLOWING
    2FUNCTION/76H Q=A1+A2*H+A3*H**2+A4*H**3+A5*H**4+A6*H**5+A7*H**6+A8*
    3H**7+A9*H**8+A10*H**9 /11H WHERE A1= ,E10.4,6H, A2= ,E10.4,6H, A3=
    4 ,E10.4,6H, A4= ,E10.4,6H, A5= ,E10.4,/7X,4HA6= ,E10.4,6H, A7= ,E1
    50.4,6H, A8= ,E10.4,6H, A9= ,E10.4,7H, A10= ,E10.4)
1040 FORMAT (1H+,22X,60H IS A DAM WHOSE HEAD AND OUTFLOW ARE KNOWN FUNC
    1TIONS OF TIME,/57H THE HEAD VS TIME CURVE IS FIT BY THE FOLLOWING
    2FUNCTION /76H H=A1+A2*T+A3*T**2+A4*T**3+A5*T**4+A6*T**5+A7*T**6+A8
    3*T**7+A9*T**8+A10*T**9 /11H WHERE A1= ,E10.4,6H, A2= ,E10.4,6H, A3
    4= ,E10.4,6H, A4= ,E10.4,6H, A5= ,E10.4,/7X,4HA6= ,E10.4,6H, A7= ,E
    510.4,6H, A8= ,E10.4,6H, A9= ,E10.4,7H, A10= ,E10.4)
1050 FORMAT (39H THE OUTFLOW VS TIME CURVE IS FIT BY    /76H Q=A1+A2*T+A
    13*T**2+A4*T**3+A5*T**4+A6*T**5+A7*T**6+A8*T**7+A9*T**8+A10*T**9 /1
    21H WHERE A1= ,E10.4,6H, A2= ,E10.4,6H, A3= ,E10.4,6H, A4= ,E10.4,6
    3H, A5= ,E10.4,/7X,4HA6= ,E10.4,6H, A7= ,E10.4,6H, A8= ,E10.4,6H, A
    49= ,E10.4,7H, A10= ,E10.4)
1060 FORMAT (1H+,22X,50H IS A DAM WHOSE HEAD IS A KNOWN FUNCTION OF TIM
    1E  ,/57H THE HEAD VS TIME CURVE IS FIT BY THE FOLLOWING FUNCTION ,
    2/76H H=A1+A2*T+A3*T**2+A4*T**3+A5*T**4+A6*T**5+A7*T**6+A8*T**7+A9*
    3T**8+A10*T**9 /11H WHERE A1= ,E10.4,6H, A2= ,E10.4,6H, A3= ,E10.4,
    46H, A4= ,E10.4,6H, A5= ,E10.4,/7X,4HA6= ,E10.4,6H, A7= ,E10.4,6H,
    5A8= ,E10.4,6H, A9= ,E10.4,7H, A10= ,E10.4)
1070 FORMAT (1H+,22X,50H IS A DAM WHOSE FLOW IS A KNOWN FUNCTION OF TIM
    1E  ,/57H THE FLOW VS TIME CURVE IS FIT BY THE FOLLOWING FUNCTION ,
    2/76H Q=A1+A2*T+A3*T**2+A4*T**3+A5*T**4+A6*T**5+A7*T**6+A8*T**7+A9*
    3T**8+A10*T**9 /11H WHERE A1= ,E10.4,6H, A2= ,E10.4,6H, A3= ,E10.4,
    46H, A4= ,E10.4,6H, A5= ,E10.4,/7X,4HA6= ,E10.4,6H, A7= ,E10.4,6H,
    5A8= ,E10.4,6H, A9= ,E10.4,7H, A10= ,E10.4)
1080 FORMAT (//,18H THIS PROBLEM HAS ,I5,21H HYDROGRAPH INPUTS   ,/)
1090 FORMAT (16H0JUNCTION NUMBER,I5)
1100 FORMAT (1H+,22X,30H IS A HYDROGRAPH INPUT NODE   /62H THE HYDROGRA
     1PH INPUT CURVE IS FIT BY THE FOLLOWING FUNCTION  /76H Q=A1+A2*T+A3
     2*T**2+A4*T**3+A5*T**4+A6*T**5+A7*T**6+A8*T**7+A9*T**8+A10*T**9 /11
     3H WHERE A1= ,E10.4,6H, A2= ,E10.4,6H, A3= ,F10.4,6H, A4= ,F10 4,6H
     4, A5= ,E10.4,/7X,4HA6= ,E10.4,6H, A7= ,E10.4,6H, A8= ,E10.4,6H, A9
     5= ,E10.4,7H, A10= ,E10.4)
1110  FOKMAT (A4)
1120  FORMAT (33A4)
1130  FORMAT (35H1END OF HYDRODYNAMIC INPUT PROGRAM )
      END
      SUBROUTINE TIDCF (AA)
C
C     ************** BATTELLE NORTHWEST 11/9/71           *************
C     ***************************************************************
C
C
C     ************** ASSIGN THE COMMON  DATA              *************
      COMMON /TAPES/N5,N6,N20,N22,N24
      COMMON/PARAMS/IZ5,IZ6,IZ9,IZ12,IZ13
C
C     ************** CONTROL AND TITLE INFORMATION        *************
      COMMON /PTINT/ NJ,NC,NJGW,NTCYC,NQSWRT,NQCYC,DELTQ,PERIOD.
     1ALPHA(30),DLP(500),IPOINT(500,6),AS(500),EVAP
      COMMON/QUAL/NCHAN(500,6),LEN(600),NJUNC(600,2),JGW(20)
      COMMON QINT,DELT,WIND,WDIR,NJSW,NHCYC,NT,ICYC,NCYC,W,
     1NEXIT,JSW(20),A0(3,20,10)
C
C     ************** JUNCTION INFORMATION                 *************
C
      COMMON H(500),VOL(500),X(500),Y(500),
     1QIN(500),QOU(500),QINST(20)
C
C     ************** CHANNEL INFORMATION                  *************
C
      COMMON B(600),R(600),A(600),AK(600),Q(600),V(600),
     1FWIND(600),NTEMP(6),NCLOS(600)
C
      REAL LEN
C     **************                   END                *************
C     ***************************************************************
C
C     ************** STAGE TIME COEFFICIENTS              *************
      DIMENSION     TT(50).AA(10),XX(10),SXX(10,10 ),SXY(10),YY(50)
      DIMENSION TITLE(33)
      DATA ASTER/5H*****/
C     ************** NAMELIST CARDS FOR INPUT OF DATA     *************
      NAMELIST /CARD1/ KO,NI.MAXIT,TT.YY
C
C                                    TIDAL CURVE FIT, 7 TERM
C                                    SINUSOIDAL EQUATION
C
      READ (N5,320) (TITLE(I),I=1,16)
      WRITE (N6,330) (TITLE(I),I=1,16)
      READ (N5,CARD1,ERR=291,END=292)
      IF (TITLE(16).EQ.ASTER) GO TO 100
      WRITE (N6,340) KO,NI,MAXIT
C                                    IF KO EQUALS ONE, PROGRAM WILL
C                                    READ FOUR POINTS OF INFORMATION
C                                    AND EXPAND THEM FOR A FULL TIDE
C
C                                    NT IS THE NUMBER OF INFORMATION
```

```
C                                                 POINTS                         N
C                                                 MAXIT IS THE MAXIMUM NUMBER OF
C                                                 ITERATIONS
C
C                                                 DELTA IS THE ACCURACY
C                                                 LIMIT IN FEET
C
      WRITE (N6,350)
      WRITE (N6,360) (TT(I),YY(I),I=1,NI)
100   CONTINUE
      DELTA=0.005
      NTT=7
      W=2.*3.14159/PERIOD
      IF (KO.EQ.0) GO TO 120
      TT(50)=TT(1)+PERIOD
      YY(50)=YY(1)
      DO 110 I=1,4
      J=I+1
      IF (J.GT.4) J=50
      NI=NI+1
      TT(NI)=(3.*TT(I)+TT(J))/4.
      YY(NI)=0.8535*YY(I)+0.1465*YY(J)
      NI=NI+1
      TT(NI)=(TT(I)+TT(J))/2.
      YY(NI)=(YY(I)+YY(J))/2.
      NI=NI+1
      TT(NI)=(TT(I)+3.*TT(J))/4.
      YY(NI)=0.1465*YY(I)+0.8535*YY(J)
110   CONTINUE
120   CONTINUE
      IF (TITLE(16).EQ.ASTER) GO TO 130
      WRITE (N6,370)
      WRITE (N6,380) (I,TT(I),YY(I),I=1,NI)
130   CONTINUE
      DO 150 J=1,NTT
      DO 140 K=1,NTT
140   SXX(K,J)=0.
      AA(J)=0.
150   SXY(J)=0.
      NJ2=NTT/2+1
      DO 190 I=1,NI
      DO 170 J=1,NTT
      FJ1=FLOAT(J-1)
      FJ3=FLOAT(J-NJ2)
      IF (J.LE.NJ2) GO TO 160
      XX(J)=COS(FJ3*W*TT(I))
      GO TO 170
160   XX(J)=SIN(FJ1*W*TT(I))
      IF (J.EQ.1) XX(J)=1.
170   SXY(J)=SXY(J)+XX(J)*YY(I)
      DO 180 J=1,NTT
      DO 180 K=1,NTT
```

```
180   SXX(K,J)=SXX(K,J)+XX(K)*XX(J)
190   CONTINUE
      IT=0
200   IT=IT+1
      DELMAX=0.
      DO 220 K=1,NTT
      SUM=0.
      DO 210 J=1,NTT
      IF (J.EQ.K) GO TO 210
      SUM=SUM-AA(J)*SXX(K,J)
210   CONTINUE
      SUM=(SUM+SXY(K))/SXX(K,K)
      DEL=ABS(SUM-AA(K))
      IF (DEL.GT.DELMAX) DELMAX=DEL
220   AA(K)=SUM
      IF (IT.GE.MAXIT) GO TO 230
      IF (DELMAX.GT.DELTA) GO TO 200
      GO TO 240
230   WRITE (N6,390) (TITLE(I),I=1,16)
      STOP 6666
240   CONTINUE
      A1=AA(1)
      A2=AA(2)
      A3=AA(3)
      A4=AA(4)
      A5=AA(5)
      A6=AA(6)
      A7=AA(7)
      IF (TITLE(16).EQ.ASTER) GO TO 250
      WRITE (N6,400)
250   CONTINUE
      RES=0.
      DO 280 I=1,NI
      SUM=0.
      DO 270 J=2,NTT
      FJ1=FLOAT(J-1)
      FJ3=FLOAT(J-NJ2)
      IF (J.LE.NJ2) GO TO 260
      SUM=SUM+AA(J)*COS(FJ3*W*TT(I))
      GO TO 270
260   SUM=SUM+AA(J)*SIN(FJ1*W*TT(I))
270   CONTINUE
      SUM=SUM+AA(1)
      DIFF=SUM-YY(I)
      RES=RES+ABS(DIFF)
      IF (TITLE(16).EQ.ASTER) GO TO 280
      WRITE (N6,410) TT(I),YY(I),SUM,DIFF
280   CONTINUE
      IF (TITLE(16).EQ.ASTER) GO TO 290
      WRITE (N6,420) RES
C
C                                        CONSTANTS FOR INPUT WAVE FORM
```

```
C
      WRITE (M6,430) A1,A2,A3,A4,A5,A6,A7,PERIOD
 290  CONTINUE
      RETURN
 291  WRITE (6,300) (TITLE(I),I=1,16)
      STOP
 292  WRITE (6,310) (TITLE(I),I=1,16)
      STOP
C     *************      FORMAT STATEMENTS                      *************
C
C
C
 300  FORMAT (' ERROR IN NAMELIST INPUT TO TIDCF '/,16A5)
 310  FORMAT (' END OF FILE ENCOUNTERED IN TIDCF '/,16A5)
 320  FORMAT (16A5)
 330  FORMAT (1H ,16A5)
 340  FORMAT (7H  KO IS,I3,19H NUMBER OF TERMS IS,I4,32H MAXIMUM NUMBER
     10F ITERATIONS IS,I4)
 350  FORMAT (25H0INPUT STAGE TIME PAIRS  /)
 360  FORMAT (2E10.4,5X,2E10.4,5X,2E10.4,5X,2E10.4,5X,2E10.4)
 370  FORMAT (29H0 NO.        TIME          VALUE )
 380  FORMAT (I4,2F12.3)
 390  FORMAT (69HCANNOT REACH DESIRED DELTA, INCREASE EITHER NI OR DELTA
     1 AND TRY AGAIN/1H ,16A5//)
 400  FORMAT (46H0       TIME    OBSERVED    COMPUTED      DIFF )
 410  FORMAT (4F12.4)
 420  FORMAT (6H0TOTAL,30X,F12.4)
 430  FORMAT (///35H COEFFICIENTS FOR TIDAL INPUT WAVE //85H      A1
     1    A2          A3          A4          A5          A6          A7      PERI
     2OD(HRS)//7F10.3,F12.2///31H WHERE THE WAVEFORM IS GIVEN BY//92H H(
     3J) = A1 + A2.SIN(WT) + A3.SIN(2WT) + A4.SIN(3WT) + A5.COS(WT) + A6
     4.COS(2WT) + A7.COS(3WT))
      END
      SUBROUTINE REGRES (ATEMP)
C
      COMMON /TAPES/N5,N6,N7,N18,N20,N22,N24
C        POLYNOMIAL REGRESSION WITH PLOTTING.
C
C        THIS MAIN PROGRAM READS THE HORIZONTAL AND VERTICAL COORDINATES
C        OF M DATA POINTS INTO THE X AND Y ARRAYS.    THE LEAST AND
C        GREATEST VALUES OF X SHOULD BE STORED IN X(1) AND X(M) RESPEC-
C        TIVELY.    THE FUNCTION REGR IS USED TO PERFORM SUCCESSIVE NTH-
C        ORDER REGRESSIONS, FROM N = MIN THROUGH N = MAX.    IN EACH
C        CASE, THE REGRESSION CURVE IS PLOTTED AGAINST THE ORIGINAL
C        DATA POINTS.
C
C     A........REGRESSION COEFFICIENT(INTERCEPT)
C     B........VECTOR CONTAINING REGRESSION COEFFICIENTS
C     DELTAX...X-SPACING FOR 26 POINTS ON THE REGRESSION CURVE
C     M........NUMBER OF DATA POINTS
C     MAX,MIN..UPPER AND LOWER LIMITS ON ORDER OF REGRESSION
C     N........ORDER, N, OF POLYNOMIAL REGRESSION
C     REGR.....FUNCTION FOR PERFORMING NTH ORDER REGRESSION
C     S........STANDARD DEVIATION OF THE POINTS ABOUT THE REGRESSION
C              LINE.   IF SIMUL ENCOUNTERS A NEAR-SINGULAR MATRIX, S IS
C              RETURNED ZERO AS A WARNING
C     X,Y......VECTORS CONTAINING THE X AND Y COORDINATES OF THE DATA
C              POINTS.
C
      DIMENSION ARRAY(50)
      DIMENSION X(100),Y(100),B(55),ARK(100),ISYM(5),CARD4(13)
      DIMENSION ATEMP(10)
      NAMELIST /CARD1/ M,MIN,MAX,X,Y
      DATA  STAR/1H*/
      DATA ASTER/6H******/CONST/6H CONST/
      DATA/ARRAY/1H1,1H2,1H3,1H4,1H5,1H6,1H7,1H8,1H9,2H10,2H11,2H12,2H13
     1,2H14,2H15,2H16,2H17,2H18,2H19,2H20,2H21,2H22,2H23,2H24,2H25,2H26,
     22H27,2H28,2H29,2H30,2H31,2H32,2H33,2H34,2H35,2H36,2H37,2H38,2H39,2
     3H40,2H41,2H42,2H43,2H44,2H45,2H46,2H47,2H48,2H49,2H50/
      DATA MMM/100/NN/55/III/25/JJJ/100/
C
C     ..... CARD1 IS TITLE CARD FOR PLOTTING .....
C     ..... READ AND CHECK COORDINATES X(1)...X(M), Y(1)...Y(M),
C           AND LOWEST AND HIGHEST REGRESSION ORDERS MIN AND MAX .....
C
      A=0.0
      DO 100 I=1,NN
  100 B(I)=0.0
      READ (N5,310) CARD4
      WRITE (6,310) CARD4
      IF (CARD4(1).NE.CONST) GO TO 110
      DECODE (CARD4(2),220) A
      GO TO 200
  110 READ (N5,CARD1,ERR=211,END=212)
```

```
      IF (MAX.LT.MIN) MAX=MIN
      IF (MIN.GE.(M-1)) GO TO 120
      IF (MAX.GE.(M-1)) MAX=M-1
      GO TO 130
120   MAX=M-1
      MIN=MAX
130   CONTINUE
      IF (MIN.LE.0) MIN=1
      IF (MAX.LE.0) MAX=1
      IF (CARD4(13).EQ.ASTER) GO TO 140
C
      WRITE (6,260) M,(X(I),Y(I),I=1,M)
      WRITE (6,270) MIN,MAX
140   CONTINUE
      DO 150 I=1,M
150   ARK(I)=STAR
      ISYM(1)=STAR
      DO 190 N=MIN,MAX
      IF (CARD4(13).EQ.ASTER) GO TO 160
      WRITE (6,250) CARD4
      WRITE (6,280) N
160   CONTINUE
C
C     ..... USE FUNCTION REGR TO PERFORM NTH-ORDER REGRESSION .....
C
      S=REGR(M,X,Y,N,A,B)
      IF (S.NE.0.0) GO TO 170
      WRITE (6,290) CARD4
      GO TO 190
170   CONTINUE
      IF (CARD4(13).EQ.ASTER) GO TO 190
      WRITE (6,300) S,A,(I,B(I),I=1,N)
C
C     ..... COMPUTE 26 POINTS LYING ON REGRESSION CURVE .....
C
      DELTAX=(X(M)-X(1))/25.0
      MP1=M+1
      MP26=M+26
      DO 180 I=MP1,MP26
      STEPS=FLOAT(I)-FLOAT(M)-1.0
      X(I)=X(1)+STEPS*DELTAX
      Y(I)=A
      ARK(I)=ARRAY(N)
      DO 180 J=1,N
180   Y(I)=Y(I)+B(J)*X(I)**J
      ISYM(2)=ARRAY(N)
C
C     ..... PLOT REGRESSION CURVE AGAINST ORIGINAL POINTS .....
C
      CALL PICTUR (M+26,III,JJJ,X,Y,ARK,ISYM,CARD4)
190   CONTINUE
200   CONTINUE
```

```
      ATEMP(1)=A
      DO 210 I=2,10
210   ATEMP(I)=B(I-1)
      RETURN
211   WRITE (6,230) CARD4
      STOP
212   WRITE (6,240) CARD4
      STOP
C
C     ..... FORMATS FOR INPUT AND OUTPUT STATEMENTS .....
C
C
C
220    FORMAT (F12 1)
230    FORMAT (' ERROR IN NAMELIST INPUT TO REGRES '/,13A6)
240    FORMAT (' END OF FILE ENCOUNTERED IN REGRES '/,13A6)
250    FORMAT (1H ,13A6)
260    FORMAT (34H  POLYNOMIAL REGRESSION, WITH M = ,I2,12H DATA POINTS//
     18X,5H X(I),8X,5H Y(I)//(2F13.2))
270    FORMAT (58H0 THE LOWEST AND HIGHEST ORDER POLYNOMIALS TO BE TRIED
     1ARE:/6X,7H MIN = ,I3,5X,7H MAX = ,I3)
280    FORMAT (32H  POLYNOMIAL REGRESSION OF ORDER/1H0,5X,7H N   = ,I3)
290    FORMAT (69H0 MATRIX C IS NEAR-SINGULAR.   REGRESSION COEFFICIENTS
     1NOT DETERMINED/1H 13A6)
300    FORMAT (1H0,5X,5H S = ,F10.6/6X,5H A = ,F10.6//(6X,3H B(,I2,4H) =
     1,F11.6))
310    FORMAT (13A6)
       END
      FUNCTION SIMUL( N, A, X, EPS, INDIC, NRC )
C
C        WHEN INDIC IS NEGATIVE, SIMUL COMPUTES THE INVERSE OF THE N BY
C        N MATRIX A IN PLACE.  WHEN INDIC IS ZERO, SIMUL COMPUTES THE
C        N SOLUTIONS X(1)...X(N) CORRESPONDING TO THE SET OF LINEAR
C        EQUATIONS WITH AUGMENTED MATRIX OF COEFFICIENTS IN THE N BY
C        N+1 ARRAY A AND IN ADDITION COMPUTES THE INVERSE OF THE
C        COEFFICIENT MATRIX IN PLACE AS ABOVE.  IF INDIC IS POSITIVE,
C        THE SET OF LINEAR EQUATIONS IS SOLVED BUT THE INVERSE IS NOT
C        COMPUTED IN PLACE.  THE GAUSS-JORDAN COMPLETE ELIMINATION METHOD
C        IS EMPLOYED WITH THE MAXIMUM PIVOT STRATEGY.  ROW AND COLUMN
C        SUBSCRIPTS OF SUCCESSIVE PIVOT ELEMENTS ARE SAVED IN ORDER IN
C        THE IROW AND JCOL ARRAYS RESPECTIVELY.  K IS THE PIVOT COUNTER,
C        PIVOT THE ALGEBRAIC VALUE OF THE PIVOT ELEMENT, MAX
C        THE NUMBER OF COLUMNS IN A AND DETER THE DETERMINANT OF THE
C        COEFFICIENT MATRIX.  THE SOLUTIONS ARE COMPUTED IN THE (N+1)TH
C        COLUMN OF A AND THEN UNSCRAMBLED AND PUT IN PROPER ORDER IN
C        X(1)...X(N) USING THE PIVOT SUBSCRIPT INFORMATION AVAILABLE
C        IN THE IROW AND JCOL ARRAYS.  THE SIGN OF THE DETERMINANT IS
C        ADJUSTED, IF NECESSARY, BY DETERMINING IF AN ODD OR EVEN NUMBER
C        OF PAIRWISE INTERCHANGES IS REQUIRED TO PUT THE ELEMENTS OF THE
C        JORD ARRAY IN ASCENDING SEQUENCE WHERE JORD(IROW(I)) = JCOL(I).
C        IF THE INVERSE IS REQUIRED, IT IS UNSCRAMBLED IN PLACE USING
C        Y(1)...Y(N) AS TEMPORARY STORAGE.  THE VALUE OF THE DETERMINANT
C        IS RETURNED AS THE VALUE OF THE FUNCTION.  SHOULD THE POTENTIAL
C        PIVOT OF LARGEST MAGNITUDE BE SMALLER IN MAGNITUDE THAN EPS,
C        THE MATRIX IS CONSIDERED TO BE SINGULAR AND A TRUE ZERO IS
C        RETURNED AS THE VALUE OF THE FUNCTION.
C
C     A.......AUGMENTED MATRIX OF COEFFICIENTS, A=(AIJ)
C     DETER....DETERMINANT OF THE ORIGINAL COEFFICIENT MATRIX
C     EPS......MINIMUM ALLOWABLE MAGNITUDE FOR A PIVOT ELEMENT
C     I,J......ROW AND COLUMN SUBSCRIPTS,RESP.
C     INDIC....COMPUTATIONAL SWITCH
C     MAX......NUMBER OF COLUMNS IN A,EITHER N OR N+1
C     N........NUMBER OF ROWS IN A
C     X........VECTOR OF SOLUTIONS
C
C     AIJCK....AIC(K)
C     INTCH....NUMD
C     INTCH....NUMBER OF PAIRWISE INTERCHANGES REQ'D TO ORDER J-VECTOR
C     IP1,KM1,NM1...I+1, K-1, AND N-1, RESP.
C     IROW.....VECTOR OF PIVOT ELEMENT ROW SUBSCRIPTS, R(K)
C     ICOL.....VECTOR OF PIVOT ELEMENT COLUMN SUBSCRIPTS, C(K)
C     IROWI,IROWJ,IROWK
C     JCOLI,JCOLJ,JCOLK...R(I),R(J),R(K),C(I),C(J),C(K), RESP.
C     ISCAN,JSCAN...INDICES USED IN PIVOT SEARCH OF VECTORS C AND R
C     JORD.....THE J VECTOR
C     JTEMP....TEMPORARY VARIABLE USED IN ORDERING THE J VECTOR
C     K........CYCLE COUNTER AND PIVOT ELEMENT SUBSCRIPT
C     NRC......ROW AND COLUMN DIMENSIONS OF STORAGE FOR THE A-MATRIX
```

```
C     PIVOT....PIVOT ELEMENT
C     Y........VECTOR USED IN UNSCRAMBLING THE INVERSE MATRIX
C
      DIMENSION IROW(50),JCOL(50),JORD(50),Y(50),A(NRC,NRC),X(50)
C
      MAX=N
      IF (INDIC.GE.0) MAX=N+1
C
C     .....IS N LARGER THAN 50 .....
      IF (N.LE.50) GO TO 100
      WRITE (6,250)
      SIMUL=0.
      RETURN
C
C     ..... BEGIN ELIMINATION PROCEDURE .....
100   DETER=1.
      DO 170 K=1,N
      KM1=K-1
C
C     ..... SEARCH FOR THE PIVOT ELEMENT .....
      PIVOT=0.
      DO 130 I=1,N
      DO 130 J=1,N
C     ..... SCAN IROW AND JCOL ARRAYS FOR INVALID PIVOT SUBSCRIPTS .....
      IF (K.EQ.1) GO TO 120
      DO 110 ISCAN=1,KM1
      DO 110 JSCAN=1,KM1
      IF (I.EQ.IROW(ISCAN)) GO TO 130
110   IF (J.EQ.JCOL(JSCAN)) GO TO 130
120   IF (DABS(A(I,J)).LE.DABS(PIVOT)) GO TO 130
      PIVOT=A(I,J)
      IROW(K)=I
      JCOL(K)=J
130   CONTINUE
C
C     ..... INSURE THAT SELECTED PIVOT IS LARGER THAN EPS .....
      IF (DABS(PIVOT).GT.EPS) GO TO 140
      SIMUL=0.
      RETURN
C
C     ..... UPDATE THE DETERMINANT VALUE .....
140   IROWK=IROW(K)
      JCOLK=JCOL(K)
      DETER=DETER*PIVOT
C
C     ..... NORMALIZE PIVOT ROW ELEMENTS .....
      DO 150 J=1,MAX
150   A(IROWK,J)=A(IROWK,J)/PIVOT
C
C     ..... CARRY OUT ELIMINATION AND DEVELOP INVERSE .....
      A(IROWK,JCOLK)=1./PIVOT
      DO 170 I=1,N
      AIJCK=A(I,JCOLK)
      IF (I.EQ.IROWK) GO TO 170
      A(I,JCOLK)=-AIJCK/PIVOT
      DO 160 J=1,MAX
160   IF (J.NE.JCOLK) A(I,J)=A(I,J)-AIJCK*A(IROWK,J)
170   CONTINUE
C
C     ..... ORDER SOLUTION VALUES (IF ANY) AND CREATE JORD ARRAY .....
      DO 180 I=1,N
      IROWI=IROW(I)
      JCOLI=JCOL(I)
      JORD(IROWI)=JCOLI
180   IF (INDIC.GE.0) X(JCOLI)=A(IROWI,MAX)
C
C     ..... ADJUST SIGN OF DETERMINANT .....
      INTCH=0
      NM1=N-1
      DO 190 I=1,NM1
      IP1=I+1
      DO 190 J=IP1,N
      IF (JORD(J).GE.JORD(I)) GO TO 190
      JTEMP=JORD(J)
      JORD(J)=JORD(I)
      JORD(I)=JTEMP
      INTCH=INTCH+1
190   CONTINUE
      IF (INTCH/2*2.NE.INTCH) DETER=-DETER
C
C     ..... IF INDIC IS POSITIVE RETURN WITH RESULTS .....
      IF (INDIC.LE.0) GO TO 200
      SIMUL=DETER
      RETURN
C
C     ..... IF INDIC IS NEGATIVE OR ZERO, UNSCRAMBLE THE INVERSE
C           FIRST BY ROWS .....
200   DO 220 J=1,N
      DO 210 I=1,N
      IROWI=IROW(I)
      JCOLI=JCOL(I)
210   Y(JCOLI)=A(IROWI,J)
      DO 220 I=1,N
220   A(I,J)=Y(I)
C     ..... THEN BY COLUMNS .....
      DO 240 I=1,N
      DO 230 J=1,N
      IROWJ=IROW(J)
      JCOLJ=JCOL(J)
230   Y(IROWJ)=A(I,JCOLJ)
      DO 240 J=1,N
240   A(I,J)=Y(J)
C
C     ..... RETURN FOR INDIC NEGATIVE OR ZERO .....
```

```
      SIMUL=DETER
      RETURN
C
C     ..... FORMAT FOR OUTPUT STATEMENT .....
C
C
C
250   FORMAT (10H0N TOO BIG)
      END
      FUNCTION REGR (M, X, Y, N, A, B )
C        FUNCTION REGR, WHICH CARRIES OUT AN NTH-ORDER POLYNOMIAL
C        REGRESSION ON M DATA POINTS CONTAINED IN THE X AND Y ARRAYS.
C        THE FUNCTION NORMALLY RETURNS THE STANDARD DEVIATION S OF THE
C        POINTS ABOUT THE REGRESSION CURVE.  THE REGRESSION COEFFICIENTS
C        ARE PLACED IN A AND B(1).. B(N).   HOWEVER, IF THE SIMULTANEOUS
C        EQUATION SOLVING ROUTINE SIMUL ENCOUNTERS A NEAR-SINGULAR
C        MATRIX, THE FUNCTION RETURNS THE VALUE 0.0
C
C     C.......MATRIX CONTAINING THE COEFFICIENTS
C     CYX.....C(I,Y) VECTOR
C     CYY.....C(Y,Y) VECTOR
C     DET.....DETERMINANT OF THE COEFFICIENT MATRIX C.
C     EPS.....TOLERANCE USED BY THE FUNCTION SIMUL
C     SIMUL...FUNCTION FOR SOLVING SIMULTANEOUS EQUATIONS
C     SX,SYX...VECTOR CONTAINING SUMMATIONS X**I AND X**I * Y
C     SY,SYY...VECTOR CONTAINING SUMMATIONS Y AND Y**2
C
      DIMENSION C(51,51),SX(100),SYX(51),CYX(51),X(100),Y(100),B(51)
      DATA EPS/ 1.0E-20/
      DATA MM/100/NN/51/
C
C     ..... COMPUTE SUMS OF POWERS AND PRODUCTS .....
      NTWO=2*N
      NP1=N+1
      SY=0.0
      SYY=0.0
      DO 100 I=1,N
      NPI=N+I
      SX(I)=0.0
      SX(NPI)=0.0
100   SYX(I)=0.0
      DO 120 I=1,M
      SY=SY+Y(I)
      SYY=SYY+Y(I)**2
      DUM=1.0
      DO 110 J=1,N
      DUM=DUM*X(I)
      SX(J)=SX(J)+DUM
110   SYX(J)=SYX(J)+Y(I)*DUM
      DO 120 J=NP1,NTWO
      DUM=DUM*X(I)
120   SX(J)=SX(J)+DUM
C
C     ..... COMPUTE COEFFICIENTS C(I,J) .....
      FM=FLOAT(M)
      CYY=SYY-SY*SY/FM
      DO 130 I=1,N
      CYX(I)=SYX(I)-SY*SX(I)/FM
      C(I,NP1)=CYX(I)
      DO 130 J=1,N
      IPJ=I+J
130   C(I,J)=SX(IPJ)-SX(I)*SX(J)/TM
C
C     ..... CALL ON SIMUL TO SOLVE SIMULTANEOUS EQUATIONS .....
      DET=SIMUL(N,C,B,EPS,1,NN)
      WRITE (6,160) DET
      IF (DET.NE.0.0) GO TO 140
      REGR=0.0
      RETURN
C
C     ..... COMPUTE INTERCEPT A AND STANDARD DEVIATION S .....
140   DUM=SY
      TEMP=CYY
      DO 150 I=1,N
      DUM=DUM-B(I)*SX(I)
150   TEMP=TEMP-B(I)*CYX(I)
      A=DUM/TM
      DENOM=FLOAT(M)-FLOAT(N)-1.0
      S=ABS(TEMP/DENOM)
      S=DSQRT(S)
      IF (S.EQ.0.) S=EPS
      REGR=S
      RETURN
C
C
C
160   FORMAT (13H0      DET = ,E14.8)
      END
      SUBROUTINE PICTUR (N,M,MCOL,XX,YY,ARK,ISYM,CARD1)
C     PROGRAMMED BY JE SCHLOSSER  1965  MODIFIED BY CA OSTER  1966
C     PRESENTS A PICTURE OF DATA ON PRINTED OUTPUT, TWO OPTIONS BEING
C     AVAILABLE
C        1   MCOL POSITIVE
C        2   MCOL NEGATIVE. IN WHICH CASE XINCREMENTS ARE TAKEN AS EQUAL
C            TO Y INCREMENTS AS DETERMINED BY M
C
C     DICTIONARY
C
C        VARIABLE   DEFINITION
C           N       NUMBER OF POINTS TO PLOT      (MAXIMUM OF 500)
C           M       MAXIMUM NUMBER OF LINES
C           MCOL    MAXIMUM NUMBER OF COLUMNS
C
C         XX(I)     X COORDINATE FOR ITH POINT
C         YY(I)     Y COORDINATE FOR ITH POINT
C         ARK(I)    MARKER FOR ITH POINT
C         ISYM(I)   PRIORITY DESIGNATOR FOR MARKER USED ON I-TH POINT
C                         (LOWER SUBSCRIPT INDICATES HIGHER PRIORITY)
C
C
      DIMENSION XX(2),YY(2),XYM(3,500),PX(6),ALF(107),ARK(2),
     1ILF(107),ISYM(5),IXYM(3,500)
      DIMENSION CARD1(13)
      EQUIVALENCE (ILF,ALF),(BLANK,LANKBA),(IXYM,XYM)
C
      DATA BLANK/1H /
C
      EXTERNAL SORDER
      N=MAX0(MIN0(500,N),2)
      XYM(1,2)=1.01
      XYM(2,2)=1.01
      XYM(3,2)=BLANK
      XMIN=1.0E37
      XMAX=-1.0E37
      DO 100 I=1,N
      XYM(1,I)=XX(I)
      XYM(2,I)=YY(I)
      XYM(3,I)=ARK(I)
      XMIN=AMIN1(XMIN,XYM(1,I))
      XMAX=AMAX1(XMAX,XYM(1,I))
100   CONTINUE
      CALL SORT (XYM,N,3,SORDER)
      YMIN=XYM(2,N)
      YMAX=XYM(2,1)
      DYLOG=ALOG10(10./FLOAT(M)*1.0E5)
      IF ((YMAX-YMIN).EQ.0.) GO TO 110
      DYLOG=ALOG10((YMAX-YMIN)/FLOAT(M)*1.0E5)
110   CONTINUE
      APROX=DYLOG-AINT(DYLOG)
      DO 120 I=2,10
      FI=I
      IF (APROX-ALOG10(FI)) 130,130,120
120   CONTINUE
130   EXACT=FI*10.0**(INT(DYLOG)-5)
      IF (MCOL) 200,140,140
140   DXLOG=ALOG10((XMAX-XMIN)/FLOAT(MCOL/2)*1.0E5)
      XAPROX=DXLOG-AINT(DXLOG)
      IF (XAPROX-.3010) 150,150,160
150   XEXACT=2.0*10.0**(INT(DXLOG)-5)
      GO TO 190
160   IF (XAPROX-.6990) 170,170,180
170   XEXACT=5.0*10.0**(INT(DXLOG)-5)
      GO TO 190
180   XEXACT=10.0**(INT(DXLOG)-4)
190   CONTINUE
      XACT=XEXACT/2.0
      GO TO 210
200   XACT=EXACT/2.0
210   TENX=20.0*XACT
      TENE=10.0*EXACT
      MAXYI=(YMAX/TENE)+(0.5+SIGN(0.5,YMAX))
      MAXXI=(XMAX/TENX)+(0.5+SIGN(0.5,XMAX))
      MINYI=(YMIN/TENE)-(0.5+SIGN(0.5,-YMIN))
      MINXI=(XMIN/TENX)-(0.5+SIGN(0.5,-XMIN))
      YFIRST=TENE*FLOAT(MAXYI)
      XFIRST=TENX*FLOAT(MINXI)
      LINES=10*(MAXYI-MINYI)+1
      KOLS=20*(MAXXI-MINXI)
      IF (KOLS-500) 230,230,220
220   WRITE (6,490) KOLS
      KOLS=500
230   IF (LINES-401) 250,250,240
240   WRITE (6,500)
      RETURN
250   CONTINUE
      LEAF=(KOLS+99)/100
      DO 430 L=1,LEAF
      DO 260 I=1,6
      PX(I)=5.*TENX*FLOAT(L-1)+TENX*FLOAT(I-1)+XFIRST
260   CONTINUE
      WRITE (6,440) CARD1
      WRITE (6,480) PX
      WRITE (6,470)
      DEX=XACT/2.0
      DEL=EXACT/2.0
      DDD=DEX+2.0*XACT
      J=1
      DO 420 I=1,LINES
      YPLOT=YFIRST-EXACT*FLOAT(I-1)
      DO 270 JKL=1,107
270   ALF(JKL)=BLANK
```

```
280   IF (J-N) 290,290,380
290   IF (XYM(1,J)-PX(1)) 370,300,300
300   CONTINUE
      IF (XYM(2,J)-(YPLOT+DEL)) 310,310,380
310   IF (XYM(2,J)-(YPLOT-DEL)) 380,320,320
320   CONTINUE
      IF (XYM(1,J)-PX(6)-DDD) 330,330,370
330   CONTINUE
      KOL=INT((XYM(1,J)+DEX-PX(1))/XACT)+4
      IF ((KOL.GT.107).OR.(KOL.LT.1)) GO TO 370
      IXYM3J=IXYM(3,J)
      ILFKOL=ILF(KOL)
      IF (ILFKOL.EQ.LANKBA) GO TO 360
      ISYM1=0
      ISYM2=0
      DO 340 IIYY=1.5
      IF (ILFKOL.EQ.ISYM(IIYY)) ISYM1=IIYY
      IF (IXYM3J.EQ.ISYM(IIYY)) ISYM2-IIYY
340   CONTINUE
      ISYMM=MIN0(ISYM1,ISYM2)
      IF (ISYMM) 370,370,350
350   ILF(KOL)=ISYM(ISYMM)
      GO TO 370
360   ALF(KOL)=XYM(3,J)
370   J=J+1
      GO TO 280
380   CONTINUE
      IF (MOD(I-1,10).NE.0) GO TO 390
      WRITE (6,450) YPLOT,ALF
      GO TO 410
390   IF (MOD(I-1,5).NE.0) GO TO 400
      WRITE (6,510) ALF
      GO TO 410
400   WRITE (6,460) ALF
410   CONTINUE
420   CONTINUE
      WRITE (6,470)
      WRITE (6,480) PX
430   CONTINUE
      RETURN
C
C
C
440   FORMAT (///////10X,13A6///)
450   FORMAT (1XF9.3,2H *107A1,1H*)
460   FORMAT (11X1HI107A1,1HI)
470   FORMAT (1H014X1H*5(20H - - - - + - - - - *)/1H )
480   FORMAT (11XF7.2,5(13XF7.2))
490   FORMAT (48H0ONLY THE FIRST 500 COLUMNS OF A PLOT REQUIRING I3,25H
     1COLUMNS WILL BE PRINTED.)
500   FORMAT (69H0NOBODY IN THEIR RIGHT MIND WOULD WANT A PLOT OF MORE T,
     1HAN 400 LINES.)
```

```
510   FORMAT (11X1H+107A1,1H+)
      END
```

```
FUNCTION SORDER(FIRST,SECOND)
DIMENSION FIRST(3),SECOND(3)
SORDER=FIRST(2)-SECOND(2)
RETURN
END
```

```
FUNCTION Q(B,C)
DIMENSION B(5), C(5)
Q=C(2)-B(2)
RETURN
END
```

```
      SUBROUTINE SORT (M,N,ITEM,Q)
C
C     ALGORITHM 245 -  TREESORT 3   FROM ACM, DEC. 1964
C                                         VOL 7   NUMBER 12, PAGE 701
C
C     PROGRAMMED BY JE SCHLOSSER
C
C
C     GENERAL PURPOSE INTERNAL SORT SUBROUTINE
C
C     EXAMPLE OF USE - - -   ASSUME -   N ITEMS OF 5 WORDS EACH
C                                       TO BE SORTED IN ASCENDING
C                                       ORDER ON THE SECOND WORD.
C     MAIN PROGRAM
C     DIMENSION A(5,1000)    N IS LESS THAN OR EQUAL TO 1000
C                            A CONTAINS THE ITEMS TO BE SORTED
C
C     EXTERNAL Q        Q IS A FUNCTION SUBROUTINE WHICH WILL RETURN
C      .                A POSITIVE NUMBER IF THE FIRST ITEM (FIRST
C      .                ARGUMENT) IS TO SORT AHEAD OF THE  SECOND
C      .                ITEM (SECOND ARGUMENT).   SEE EXAMPLE BELOW.
C
C     CALL SORT (A,N,5,Q)   ARGUMENT    MEANING
C      .                     FIRST      ARRAY CONTAINING ITEMS
C      .                     SECOND     NUMBER OF ITEMS
C      .                     THIRD      NUMBER OF WORDS PER ITEM
C      .                     FOURTH     FUNCTION SUBROUTINE TO
C      .                                        DEFINE SORT ORDER
C
C     FUNCTION Q(B,C)         WRITE A FUNCTION SUBROUTINE SUCH AS THIS.
C     DIMENSION B(5),C(5)     IT SHOULD RETURN A POSITIVE RESULT IF
C     Q=C(2)-B(2)             THE FIRST ARGUMENT SHOULD SORT AHEAD
C     RETURN                  OF THE SECOND ARGUMENT.  THIS ROUTINE
C     END                     PRODUCES AN ASCENDING SORT ON THE SECOND
C                             WORD  OF THE ITEMS.
C
C     NOTE - -  THE MAXIMUM NUMBER OF WORDS PER ITEM IS LIMITED
C     BY THE DIMENSION OF KOPY.      THIS LIMIT IS PRESENTLY 100.
C
C     APPROXIMATE SPEED IS 250 ITEMS PER SECOND.
      INTEGER Q
      DIMENSION KOPY (100)
      DIMENSION M(ITEM,N)
      IF (N-1) 320,320,100
100   K=N/2+1
      L=N/2-1
      IF (L) 210,210,110
110   CONTINUE
      DO 200 II=1,L
      I=K-II
      IS=I
      NS=N
      DO 120 IQ=1,ITEM
120   KOPY(IQ)=M(IQ,IS)
130   J=2*IS
      IF (J.GT.NS) GO TO 180
      IF (J.GE.NS) GO TO 150
      IF (Q(M(1,J+1),M(1,J))) 140,150,150
140   J=J+1
150   IF (Q(M(1,J),KOPY)) 160,180,180
160   DO 170 IQ=1,ITEM
170   M(IQ,IS)=M(IQ,J)
      IS=J
      GO TO 130
180   DO 190 IQ=1,ITEM
190   M(IQ,IS)=KOPY(IQ)
200   CONTINUE
210   NPLUS-N+2
      DO 310 II=2,N
      I=NPLUS-II
      IS=1
      NS=I
      DO 220 IQ=1,ITEM
220   KOPY(IQ)=M(IQ,IS)
230   J=2*IS
      IF (J.GT.NS) GO TO 280
      IF (J.GE.NS) GO TO 250
      IF (Q(M(1,J+1),M(1,J))) 240,250,250
240   J=J+1
250   IF (Q(M(1,J),KOPY)) 260,280,280
260   DO 270 IQ=1,ITEM
270   M(IQ,IS)=M(IQ,J)
      IS=J
      GO TO 230
280   DO 290 IQ=1,ITEM
290   M(IQ,IS)=KOPY(IQ)
      DO 300 IT=1,ITEM
      LAZY=M(IT,1)
      M(IT,1)=M(IT,I)
      M(IT,I)=LAZY
300   CONTINUE
310   CONTINUE
320   CONTINUE
      RETURN
      END
```

FIGURE C-9. LISTING OF THE HYDRAULIC CALCULATIONAL COMPUTER PROGRAM FOR EXPLORE-I

```
C     MAIN PROGRAM TO COORDINATE THE CALCULATION AND PLOTTING PROGRAM
C     SCRATCH UNITS ARE SCRATCH TAPES
      COMMON /TAPES/N5,N6,N20,N22,N24
      COMMON/PARAMS/IZ5,IZ6,IZ9,IZ12,IZ13
C
      N5=5
      N6=6
C
      IZ5=500
      IZ6=6
      IZ9=600
      IZ12=20
      IZ13=20
      N20=2
      N22=N20
      N24=1
      REWIND N20
      REWIND N22
      REWIND N24
      CALL HYDCAL
      CALL HYDPLT
      STOP
      END
```

```
C     SUBROUTINE HYDCAL
C
C     ************** BATTELLE NORTHWEST 11/9/71              **************
C     **********************************************************************
C
C
C     ************** ASSIGN THE COMMON  DATA                 **************
      COMMON /TAPES/N5,N6,N20,N22,N24
      COMMON/PARAMS/I25,I26,I29,IZ12,IZ13
C
C     ************** CONTROL AND TITLE INFORMATION           **************
      COMMON /PRINT/ NJ,NC,NTCYC,NQCYC,DELTQ,PERIOD,ALPHA(30),
     1DEP(500),NQSWRT
      COMMON/QUAL/NCHAN(500,6),AS(500),LEN(600),NJUNC(600,2)
      COMMON QINT,DELT,WIND,WDIR,NJSW,NJGW,NHCYC,NT,ICYC,NCYC,W,
     1NEXIT,JSW(20),JGW(20),A0(3,20,10)
C
C     ************** JUNCTION INFORMATION                    **************
C
      COMMON H(500),HN(500),HT(500),HBAR(500),HAVE(500),
     1IPOINT(500,6),VOL(500),X(500),Y(500),QIN(500),QOU(500),
     2QINST(20),QINBAR(500),QOUBAR(500)
C
C     ************** CHANNEL INFORMATION                     **************
C
      COMMON B(600),R(600),A(600),AT(600),AK(600),Q(600),QBAR(600),
     1QAVE(600),V(600),VT(600),VBAR(600),FWIND(600),NTEMP(6),
     2NCLOS(600)
      COMMON NTRIB,TRBDEP(50),ITRIB(50,2)
C
      REAL LEN
      DIMENSION ARRAY(33)
C     **************                 END                     **************
C     **********************************************************************
C
C
      DATA ASTERK/4H****/
C
C
C     ************** INPUT AND PRINT THE INPUT HYDRAULIC DATA **********
100   CONTINUE
      READ (N20,1100) ARRAY
      IF (ARRAY(1).EQ.ASTERK) GO TO 110
      WRITE (N6,1100) ARRAY
      GO TO 100
110   CONTINUE
      READ (N20) NTCYC,PERIOD,QINT,DELT,WIND,WDIR,NQSWRT,NJSW,NJGW
     1,(JSW(L),QINST(L),((A0(I,L,N),I=1,3),N=1,10),L=1,IZ12),(JGW(L),L=1
     2,IZ13),(ALPHA(I),I=1,30),NQCYC,NHCYC,NT,DELTQ,ICYC,NCYC,NEXIT,NJ,N
     3C,((NCHAN(I,II),IPOINT(I,II),II=1,IZ6),H(I),HN(I),HT(I),HBAR(I),HA
     4VE(I),AS(I),VOL(I),X(I),Y(I),DEP(I),QIN(I),QOU(I),QINBAR(I),QOUBAR
     5(I),I=1,NJ),((NJUNC(N,L),L=1,2),LEN(N),B(N),R(N),A(N),AT(N),AK(N),
     6Q(N),QBAR(N),QAVE(N),V(N),VT(N),VBAR(N),FWIND(N),NCLOS(N),N=1,NC),
     7EVAP,NTRIB,(TRBDEP(I),ITRIB(I,1),ITRIB(I,2),I=1,50)
C     **************             END                      *************
C
C
C     **************  WRITE OUT HYDRAULIC DATA TO QUALITY TAPE *********
      REWIND N22
      WRITE (N22) (ALPHA(I),I=1,30),NJ,NC,NQCYC,DELTQ,NTCYC,NQSWRT,NJGW,
     1EVAP,((NCHAN(J,K),K=1,IZ6),DEP(J),AS(J),J=1,NJ),(LEN(N),(NJUNC(N,K
     2),K=1,2),N=1,NC),PERIOD,(JGW(I),I=1,NJGW)
      WRITE (N22) ((IPOINT(J,K),K=1,IZ6),J=1,NJ)
C     **************             END                      *************
C
C     **************         INITIALIZATION               *************
      NJGM1=NJGW+1
      DELT2=DELT/2.0
      W=6.2832/(3600.*PERIOD)
      T=0.0
      TIME=0.
C     **************             END                      *************
C
C     ********** THIS LOOP CALCULATES THE CONTROLLED NODE INITIAL******
C     ********** CONTITIONS                                       ******
      DO 180 J=1,NJGW
      IJK=JGW(J)
      GO TO (180,120,130,140,150,160), IJK
C     WIER RELATIONS  REQUIRE NO CALCULATION AT THIS POINT
C     1801
C     TIDAL CONTROL STAGE
120   CALL GENFUN (T,H(J),1,J,T)
      Q(J)=0.
      GO TO 170
C     DAM IS OPERATED VIA A Q VS H CURVE
130   CALL GENFUN (H(J),Q(J),1,J,TIME)
      GO TO 170
C     DAM WHOSE HEAD AND OUTFLOW ARE KNOWN FUNCTIONS OF TIME
140   CALL GENFUN (H(J),Q(J),1,J,TIME)
      GO TO 170
C     DAM WHOSE HEAD IS A KNOWN FUNCTION OF TIME AND WHOSE OUTFLOW IS
C     DETERMINED FROM A MASS BALANCE
150   CALL GENFUN (TIME,H(J),1,J,TIME)
      Q(J)=0.
      GO TO 170
C     DAM WHOSE OUTFLOW IS A KNOWN FUNCTION OF TIME AND WHOSE HEAD IS
C     DETERMINED FROM A MASS BALANCE
160   CALL GENFUN (TIME,Q(J),1,J,TIME)
170   V(J)=0.
180   CONTINUE
C     **************             END                      *************
C
C     ************** COMPUTE THE CHANNEL CONSTANTS
```

```
      DO 240 N=1,NC
      IF ((NJUNC(N,1).EQ.0).AND.(N.LE.NJGW)) GO TO 190
      IF (NJUNC(N,1).LE.0) GO TO 240
190   CONTINUE
      AK(N)=32.1739*AK(N)**2/2.208196
      NL=NJUNC(N,1)
      NH=NJUNC(N,2)
      IF (N.LE.NJGW) NL=NH
      R(N)=R(N)+(H(NL)+H(NH))/2.
      IF (NTRIB.LE.0) GO TO 220
      DO 200 I=1,NTRIB
      IF (N.EQ.ITRIB(I,1)) GO TO 210
200   CONTINUE
      GO TO 220
210   IJN=ITRIB(I,2)
      IF (IJN.EQ.NL) IHJN=NH
      IF (IJN.EQ.NH) IHJN=NL
      R(N)=H(IJN)+DEP(IJN)
      IF (H(IHJN).LT.H(IJN)) GO TO 220
      R(N)=(H(IHJN)+DEP(IHJN)+H(IJN)+DEP(IJN))/2.
220   CONTINUE
      A(N)=B(N)*R(N)
      IF (WIND.LE.0.0) GO TO 230
      FWIND(N)=-WIND**2*COS(WDIR/57.-ATAN2((X(NH)-X(NL)),(Y(NH)-Y(NL))))
     1*3.64E-6
230   CONTINUE
      AT(N)=A(N)
      QAVE(N)=0.
240   CONTINUE
C     **************              END                       *************
C
C     **************    COMPUTE THE NODAL VOLUMES           *************
      DO 260 J=1,NJ
      VOL(J)=0.
      IF (AS(J).EQ.0.) GO TO 260
      AREA=0.
      VOLUME=0.
      DO 250 K=1,IZ6
      N=NCHAN(J,K)
      IF (N.LE.0) GO TO 250
      AREA=AREA+B(N)*LEN(N)
      VOLUME=VOLUME+B(N)*LEN(N)*R(N)
250   CONTINUE
      DEPTH=VOLUME/AREA
      VOL(J)=DEPTH*AS(J)
260   CONTINUE
C     **************              END                       *************
C
C
C     ************** START OF OUTER DO LOOP *****************************
C     ********************************************************************
C     NT=THE DAILY CYCLE NUMBER
```

```
C     NTCYC=THE NUMBER OF DAILY CYCLES TO BE SIMULATED
C     ******************************************************************
C     ******************************************************************
C
C
      DO 910 NT=1,NTCYC
      HOUR=0.0
C
C
C     ************ START OF THE 2ND OF THREE NESTED DO LOOPS **********
C     ******************************************************************
C     NQ=THE QUALITY CYCLE NUMBER
C     NQCYC=THE NUMBER OF QUALITY CYCLES PER DAILY CYCLE
C     ******************************************************************
C     ******************************************************************
C
C
      DO 900 NQ=1,NQCYC
C
C     ************** INITIALIZE THE OUTPUT ARRAYS FOR THE SWQUAL ROUTINE
      DO 270 N=1,NC
      VBAR(N)=0.
  270 QBAR(N)=0.
      DO 280 J=1,NJ
      HBAR(J)=0.
      QINBAR(J)=0.
      QOUBAR(J)=0.
  280 CONTINUE
C     **************              END                     *************
C
C
C     ************* START OF THE THIRD OF THREE  NESTED DO LOOPS *******
C     ******************************************************************
C     NHH=THE HYDRAULIC CYCLE COUNTER
C     NHCYC=THE NUMBER OF HYDRAULIC CYCLES PER QUALITY CYCLE
C     ******************************************************************
C     ******************************************************************
C
C
      DO 860 NHH=1,NHCYC
C     ******************************************************************
C     TIME IS THE TIMING VARIABLE THAT BEGINS AFTER THE FLOW PATTERNS
C     HAVE REACHED EQUILIBRIUM
C     ******************************************************************
      IF (NT.LT.NQSWRT) GO TO 300
      TIME=TIME+DELT
      TIM2=TIME-DELT2
C
C     *********** HYDROGRAPH INPUTS ************************************
      IF (NJSW.EQ.0) GO TO 300
      DO 290 L=1,NJSW
      J=JSW(L)
      CALL GENFUN (TIME,QIN(J),2,L,TIME)
290   QIN(J)=QINST(L)+QIN(J)
C     *************             END                    *************
C
C
C     **************         INITIALIZATION            *************
300   CONTINUE
      T2=T+DELT2
      T=T+DELT
      DO 310 N=1,NC
      NCLOS(N)=0
      DO 310 M=1,2
310   NJUNC(N,M)=IABS(NJUNC(N,M))
      DO 320 J=1,NJ
      AS(J)=ABS(AS(J))
      DO 320 K=1,IZ6
320   NCHAN(J,K)=IABS(NCHAN(J,K))
      NTIMS=0
C     **************            END                    *************
C
C     ************** COMPUTATION OF VELOCITIES  AT 1/2 DELT   **********
C     ************** AND FLOWS AT 1/4 DELT                 ************
330   CONTINUE
      NDRY=0
      NTIMS=NTIMS+1
      DO 380 N=NJGW1,NC
      IF (NJUNC(N,1).LE.0) GO TO 380
C     ************** DRY CHANNEL CHECK (UNDER 0.1 FEET)    *************
      IF (R(N).GT.0.01) GO TO 340
      VT(N)=0.0
      Q(N)=0.0
      GO TO 380
340   CONTINUE
      NL=NJUNC(N,1)
      NH-NJUNC(N,2)
      DELTH=H(NH)-H(NL)
      IF (NTRIB.LE.0) GO TO 370
      DO 350 IL=1,NTRIB
      IF (N.EQ.ITRIB(IL,1)) GO TO 360
350   CONTINUE
      GO TO 370
360   IJN=ITRIB(IL,2)
      IF (IJN.EQ.NL) IHJN=NH
      IF (IJN.EQ.NH) IHJN=NL
      DELTH=-DEP(IJN)+TRBDEP(IL)
      IF (IJN.LT.IHJN) DELTH=-DELTH
      IF (H(IJN).LT.H(IHJN)) DELTH=H(NH)-H(NL)
370   CONTINUE
      DELV2=V(N)*(1.-AT(N)/A(N))+DELT2*((V(N)**2*B(N)/A(N))-32.1739)*DEL
     1TH/LEN(N)+FWIND(N)/R(N)*DELT2
      V2=V(N)+DELV2
      TEMP=DELT2*AK(N)/R(N)**1.3333333
      DELV1=0.5*((1./TEMP+2.*ABS(V2))-SQRT((1./TEMP+ABS(2.*V2))**2-4.*V2
     1**2))
      DELV1=-SIGN(DELV1,V2)
      VT(N)=V(N)+DELV1+DELV2
      Q(N)=VT(N)*A(N)
  380 CONTINUE
C     *************              END                          ************
C
C     ************* CONTROLLED NODE CALCULATIONS *********************
C     ************** FLOW AT 1/4 DELT AND HEAD AT 1/2 DELT *************
C     *****************************************************************
      DO 470 J=1,NJGW
      SUMQ=0.
      DO 400 K=1,I76
      IF (NCHAN(J,K).EQ.J) GO TO 400
      IF (NCHAN(J,K).LE.0) GO TO 400
      N=NCHAN(J,K)
      IF (J.NE.NJUNC(N,1)) GO TO 390
      SUMQ=SUMQ+Q(N)
      GO TO 400
  390 SUMQ=SUMQ-Q(N)
  400 CONTINUE
      SUMQ=SUMQ+QOU(J)-QIN(J)+EVAP*AS(J)
      IJK=JGN(J)
      GO TO (410,420,430,440,450,460), IJK
C     WEIR RELATIONSHIP
  410 CALL GENFUN (SUMQ,DELHH,1,J,DELT2)
      Q(J)=-DELHH*AS(J)/DELT2-SUMQ
      IF (Q(J).LT.0.) Q(J)=0.
      VT(J)=0.
      HT(J)=H(J)+DELHH
      GO TO 470
C     TIDAL CONTROL STAGE
  420 CALL GENFUN (T2,HT(J),1,J,T2)
      Q(J)=-SUMQ-(HT(J)-H(J))*AS(J)/DELT2
      VT(J)=0.
      GO TO 470
C     DAM IS OPERATED ACCORDING TO A Q VS H OPERATION POLICY
  430 CALL GENFUN (H(J),Q(J),1,J,TIM2)
      SUMQ=SUMQ+Q(J)
      HT(J)=H(J)-DELT2*SUMQ/AS(J)
      VT(J)=0.
      GO TO 470
C     DAM WHOSE HEAD AND OUTFLOW ARE KNOWN FUNCTIONS OF TIME
  440 CALL GENFUN (HT(J),Q(J),1,J,TIM2)
      VT(J)=0.
      GO TO 470
C     DAM WHOSE HEAD IS A KNOWN FUNCTION OF TIME AND WHOSE OUTPUT IS
C     DETERMINED FROM A MASS BALANCE
  450 CALL GENFUN (TIM2,HT(J),1,J,TIM2)
      Q(J)=-SUMQ-(HT(J)-H(J))*AS(J)/DELT2
      IF (Q(J).LT.0.) Q(J)=0.
      VT(J)=0.
      GO TO 470
C     DAM WHOSE OUTFLOW IS A KNOW FUNCTION OF TIME AND WHOSE HEAD IS
C     DETERMINED FROM A MASS BALANCE
460   CALL GENFUN (TIM2,Q(J),1,J,TIM2)
      SUMQ=SUMQ+Q(J)
      HT(J)=H(J)-DELT2*SUMQ/AS(J)
      VT(J)=0.
470   CONTINUE
C     **************              END                 **************
C     **********************************************************************
C
C     ************** REGULAR NODES STAGE AT 1/2 DELT        **************
      DO 510 J=NJGW1,NJ
      SUMQ=0.
      DO 490 K=1,IZ6
      IF (NCHAN(J,K).LE.0) GO TO 490
      N=NCHAN(J,K)
      IF (J.NE.NJUNC(N,1)) GO TO 480
      SUMQ=SUMQ+Q(N)
      GO TO 490
480   SUMQ=SUMQ-Q(N)
490   CONTINUE
      IF (AS(J).LE.0.) GO TO 510
      SUMQ=SUMQ+QOU(J)-QIN(J)+EVAP*AS(J)
      HT(J)=H(J)-DELT2*SUMQ/AS(J)
      IF (HT(J)+DEP(J).GT.0.) GO TO 510
      HT(J)=-DEP(J)
      VOL(J)=0.
      AS(J)=-AS(J)
      DO 500 K=1,IZ6
      NX=NCHAN(J,K)
      IF (NX.LE.0) GO TO 500
      IF (NX.LE.NJGW) GO TO 500
      NCLOS(NX)=1
500   CONTINUE
      NDRY=NDRY+1
510   CONTINUE
      IF (NDRY.EQ.0) GO TO 560
      IF (NTIMS.GT.2) GO TO 560
      DO 550 N=NJGW1,NC
      IF (NJUNC(N,1).LE.0) GO TO 550
      IF (NCLOS(N).NE.1) GO TO 550
      Q(N)=0.
      V(N)=0.
      DO 540 I=1,2
      II=NJUNC(N,I)
      DO 520 J=1,IZ6
      IF (NCHAN(II,J).EQ.N) GO TO 530
520   CONTINUE
      GO TO 540
530   NCHAN(II,J)=-N
```

```
  540 NJUNC(N,I)=-II
  550 CONTINUE
      GO TO 330
  560 CONTINUE
C     **************            END                        *************
C
C
C     ************** COMPUTATION OF CROSSECTIONAL AREA AND FLOW AT 1/2 D
C     ************** AND VELOCITIES AT THE FULL DELT       *************
      DO 630 N=NJGW1,NC
      IF (NJUNC(N,1).LE.0) GO TO 630
      NL=NJUNC(N,1)
      NH=NJUNC(N,2)
      DELH=0.5*(HT(NH)-H(NH)+HT(NL)-H(NL))
      DELTH=HT(NH)-HT(NL)
      IF (NTRIB.LE.0) GO TO 590
      DO 570 IL=1,NTRIB
      IF (N.EQ.ITRIB(IL,1)) GO TO 580
  570 CONTINUE
      GO TO 590
  580 IJN=ITRIB(IL,2)
      IF (IJN.EQ.NH) IHJN=NL
      IF (IJN.EQ.NL) IHJN=NH
      IF (HT(IJN).LT.HT(IHJN)) GO TO 590
      DELH=HT(IJN)-H(IJN)
      DELTH=-DEP(IJN)+TRBDEP(IL)+DELH
      IF (IJN.LT.IHJN) DELTH=-DELTH
  590 CONTINUE
      RNT=R(N)+DELH
      AT(N)=A(N)+B(N)*DELH
C     ************** DRY CHANNEL CHECK  (UNDER 0.1 FEET)   *************
      IF (RNT.GT.0.01) GO TO 600
      V(N)=0.
      Q(N)=0.
      GO TO 610
  600 CONTINUE
      DELV2=2.*VT(N)*(1.-A(N)/AT(N))+DELT*((VT(N)**2*B(N)/AT(N))-32.1739
     1)*(DELTH)/LEN(N)+FWIND(N)/RNT*DELT
      V2=V(N)+DELV2
      TEMP=DELT*AK(N)/RNT**1.3333333
      DELV1=0.5*((1./TEMP+2.*ABS(V2))-SQRT((1./TEMP+2.*ABS(V2))**2-4.*V2
     1**2))
      DELV1=-SIGN(DELV1,V2)
      V(N)=V(N)+DELV1+DELV2
      Q(N)=0.5*(Q(N)+V(N)*AT(N))
  610 CONTINUE
C     ************** SUM THE CHANNEL FLOWS                 *************
      IF (NT.LT.NQSWRT) GO TO 620
      QBAR(N)=QBAR(N)+Q(N)
      VBAR(N)=VBAR(N)+V(N)
  620 CONTINUE
C     ************** CHECK FOR EXCESSIVE VELOCITIES        *************
      IF (ABS(V(N)).LE.20.0) GO TO 630
      WRITE (N6,1110) NT,NQ,NHH,R(N),V(N),N
630   CONTINUE
C     **************          END                    *************
C
C     ************* CONTROLLED NODE CALCULATIONS AT FULL TIME STEP *****
C     ******************************************************************
      DO 740 J=1,NJGW
      SUMQ=0.
      DO 650 K=1,IZ6
      IF (NCHAN(J,K).EQ.J) GO TO 650
      IF (NCHAN(J,K).LE.0) GO TO 650
      N=NCHAN(J,K)
      IF (J.NE.NJUNC(N,1)) GO TO 640
      SUMQ=SUMQ+Q(N)
      GO TO 650
640   SUMQ=SUMQ-Q(N)
650   CONTINUE
      SUMQ=SUMQ+QOU(J)-QIN(J)+EVAP*AS(J)
      IJK=JGW(J)
      GO TO (660,680,690,700,710,720), IJK
C     WEIR RELATIONSHIP
660   CALL GENFUN (SUMQ,DELHH,1,J,DELT)
      Q(J)=-DELHH*AS(J)/DELT-SUMQ
      IF (Q(J).LT.0.) Q(J)=0.
      V(J)=0.
      HN(J)=H(J)+DELHH
670   DVOL=(HN(J)-H(J))*AS(J)
      VOL(J)=VOL(J)+DVOL
      GO TO 730
C     TIDAL CONTROL STAGE
680   CALL GENFUN (T,HN(J),1,J,T)
      Q(J)=-SUMQ-(HN(J)-H(J))*AS(J)/DELT
      V(J)=0.
      GO TO 670
C     DAM OPERATED ACCORDING TO A Q VS H OPERATING POLICY
690   CALL GENFUN (HT(J),QJ2,1,J,TIME)
      Q(J)=(Q(J)+QJ2)/2.
      SUMQ=SUMQ+Q(J)
      HN(J)=H(J)-DELT*SUMQ/AS(J)
      V(J)=0.
      GO TO 670
C     DAM WHOSE HEAD AND OUTFLOW ARE KNOWN FUNCTIONS OF TIME
700   CALL GENFUN (HN(J),QJ2,1,J,TIME)
      Q(J)=(Q(J)+QJ2)/2.
      V(J)=0.
      GO TO 670
C     DAM WHOSE HEAD IS A KNOWN FUNCTION OF TIME AND WHOSE OUTFLOW
C     IS DETERMINED FROM A MASS BALANCE
710   CALL GENFUN (TIME,HN(J),1,J,TIME)
      Q(J)=-SUMQ-(HN(J)-H(J))*AS(J)/DELT
      IF (Q(J).LT.0.) Q(J)=0.
      V(J)=0.
      GO TO 670
C     DAM WHOSE OUTFLOW IS A KNOWN FUNCTION OF TIME AND WHOSE HEAD IS
C     COMPUTED FROM A MASS BALANCE
720   CALL GENFUN (TIME,QJ2,1,J,TIME)
      Q(J)=(Q(J)+QJ2)/2.
      SUMQ=SUMQ+Q(J)
      HN(J)=H(J)-DELT*SUMQ/AS(J)
      V(J)=0.
      GO TO 670
C
C     ************** SUM THE CHANNEL FLOWS FOR THE CONTROL NODES *******
730   IF (NT.LT.NQSWRT) GO TO 740
      QBAR(J)=QBAR(J)+Q(J)
      VBAR(J)=VBAR(J)+V(J)
C     **************                END                     *************
C
740   CONTINUE
C     **************                END                     *************
C     *****************************************************************
C
C
C     ************** COMPUTATION OF NODAL STAGE AND VOLUME AT FULL DELT
      DO 770 J=NJGW1,NJ
      SUMQ=0.
      HN(J)=-DEP(J)
      IF (AS(J).LE.0. ) GO TO 770
      DO 760 K=1,IZ6
      IF (NCHAN(J,K).LE.0) GO TO 760
      N=NCHAN(J,K)
      IF (J.NE.NJUNC(N,1)) GO TO 750
      SUMQ=SUMQ+Q(N)
      GO TO 760
750   SUMQ=SUMQ-Q(N)
760   CONTINUE
      SUMQ=SUMQ+QOU(J)-QIN(J)+EVAP*AS(J)
      HN(J)=H(J)-DELT*SUMQ/AS(J)
      VOL(J)=VOL(J)-DELT*SUMQ
770   CONTINUE
C     **************                END                     *************
C
C     ************** SUM NODAL VOLUMES AND FLOWS                *************
      IF (NT.LT.NQSWRT) GO TO 790
      DO 780 J=1,NJ
      HBAR(J)=HBAR(J)+HN(J)
      QINBAR(J)=QINBAR(J)+QIN(J)
      QOUBAR(J)=QOUBAR(J)+QOU(J)
780   CONTINUE
790   CONTINUE
C     **************                END                     *************
C
C     ************** CALCULATE THE HYDRAULIC RADIUS AND CHANNEL CROSSECT
C     ************** AREA AT THE FULL DELT                      *************
      DO 840 N=NJGW1,NC
      IF (NJUNC(N,1).EQ.0) GO TO 840
      NL=IABS(NJUNC(N,1))
      NH=IABS(NJUNC(N,2))
      DELH=0.5*(HN(NH)-H(NH)+HN(NL)-H(NL))
      IF (NTRIB.LE.0) GO TO 830
      DO 800 IL=1,NTRIB
      IF (N.EQ.ITRIB(IL,1)) GO TO 810
800   CONTINUE
      GO TO 830
810   IJN=ITRIB(IL,2)
      IF (IJN.EQ.NL) IHJN=NH
      IF (IJN.EQ.NH) IHJN=NL
      IF (HN(IJN).LT.HN(IHJN)) GO TO 820
      R(N)=HN(IJN)+DEP(IJN)
      A(N)=B(N)*R(N)
      GO TO 840
820   R(N)=(0.5)*(HN(IHJN)+DEP(IHJN)+HN(IJN)+DEP(IJN))
      A(N)=B(N)*R(N)
      GO TO 840
830   CONTINUE
      R(N)=R(N)+DELH
      A(N)=A(N)+B(N)*DELH
840   CONTINUE
C     ***************              END                   *************
C
C     *************** SHIFT THE NODAL ARRAYS             *************
      DO 850 J=1,NJ
850   H(J)=HN(J)
C     ***************              END                   *************
C
C
C     ************* STATEMENT 860 IS THE END OF ONE HYDRAULIC CYCLE ****
860   CONTINUE
C     ****************************************************************
C
C     *************** AVERAGE THE FLOWS AND VELOCITIES    *************
C     *************** FOR USE BY THE PRINTOUT AND SWQUAL  *************
      IF (NT.LT.NQSWRT) GO TO 900
      DO 880 N=1,NC
      IF (N.LE.NJSW) GO TO 870
      IF (NJUNC(N,1).LE.0) GO TO 880
870   CONTINUE
      QBAR(N)=QBAR(N)/FLOAT(NHCYC)
      VBAR(N)=VBAR(N)/FLOAT(NHCYC)
      QAVE(N)=QAVE(N)+QBAR(N)/FLOAT(NQCYC)
880   CONTINUE
      DO 890 J=1,NJ
      QINBAR(J)=QINBAR(J)/FLOAT(NHCYC)
      QOUBAR(J)=QOUBAR(J)/FLOAT(NHCYC)
      HBAR(J)=HBAR(J)/FLOAT(NHCYC)
      IF (QINBAR(J).EQ.0.) GO TO 890
      IF (QOUBAR(J).EQ.0.) GO TO 890
      QINBAR(J)=QINBAR(J)-QOUBAR(J)
      QOUBAR(J)=0.
      IF (QINBAR(J).GT.0.) GO TO 890
      QOUBAR(J)=-QINBAR(J)
      QINBAR(J)=0.
890   CONTINUE
C     **************              END                   *************
C
C     ************** WRITE OUT THE HYDRAULIC INFORMATION   *************
C     ************** FOR USE BY THE SWQUAL PROGRAM         *************
      WRITE (N22) NT,NQ,(HBAR(J),VOL(J),QINBAR(J),QOUBAR(J),J=1,NJ),(QBA
     1R(N),VBAR(N),N=1,NC)
C     **************             END                    *************
C
C     ************** WRITE THE HYDRAULIC INFORMATION       *************
C     ************** TO FAST DRUM FOR LATER USE            *************
C     ************** BY THE PRINTING AND PLOT PROGRAM      *************
      WRITE (N24) NT,NQ
      WRITE (N24) (HBAR(J),J=1,NJ)
      WRITE (N24) (VOL(J),J=1,NJ)
      WRITE (N24) (QINBAR(J),J=1,NJ)
      WRITE (N24) (QOUBAR(J),J=1,NJ)
      WRITE (N24) (QBAR(N),N=1,NC)
      WRITE (N24) (VBAR(N),N=1,NC)
C     **************                END                 *************
C
C     ************* STATEMENT 1240 IS THE END OF ONE QUALITY CYCLE *****
900   CONTINUE
C     ******************************************************************
C
C
C     ************* STATEMENT 1300 IS THE END OF ONE DAILY CYCLE********
910   CONTINUE
C     ******************************************************************
C
C
      END FILE N22
      REWIND N20
      REWIND N22
      READ (5,1020) IDECK
      IF (IDECK.EQ.0) GO TO 1010
      PUNCH 1030, (ALPHA(I),I=1,30)
      PUNCH 1040, NTCYC,PERIOD,QINT,DELT,EVAP,WIND,WDIR,NQSWRT,NJS
     1W,NJGW,NTRIB
      IF (NJSW.LE.0) GO TO 920
      PUNCH 1050, (JSW(L),L=1,NJSW)
920   CONTINUE
      PUNCH 1050, (JGW(L),L=1,NJGW)
      IF (NTRIB.LE.0) GO TO 940
      DO 930 I=1,NTRIB
      PUNCH 1060, ITRIB(I,1),ITRIB(I,2)
930   CONTINUE
```

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 940  CONTINUE
      DO 950 J=1,NJ
      RAD=-DEP(J)
      PUNCH 1070,  J,H(J),AS(J),QIN(J),QOU(J),RAD,X(J),Y(J)
 950  CONTINUE
      PUNCH 1080
      DO 1000 N=1,NC
      IF (NTRIB.LE.0) GO TO 980
      DO 960 IL=1,NTRIB
      IF (ITRIB(IL,1).EQ.N) GO TO 970
 960  CONTINUE
      GO TO 980
 970  IJN=ITRIB(IL,2)
      RAD=0.5*(-DEP(IJN)-TRBDEP(IL))
      GO TO 990
 980  NH=NJUNC(N,1)
      NL=NJUNC(N,2)
      IF (NH.EQ.0) NH=NL
      IF (NL.EQ.0) NL=NH
      RAD=0.5*(-DEP(NL)-DEP(NH))
 990  CONTINUE
      AK(N)=SQRT(AK(N)*2.208196/32.1739)
      PUNCH 1090,  N,NJUNC(N,1),NJUNC(N,2),LEN(N),B(N),RAD,AK(N),V(N)
1000  CONTINUE
      PUNCH 1080
1010  CONTINUE
      WRITE (N6,1120)
C     **************             END                  *************
C     **************             END                  *************
C     **************             END                  *************
C     **************             END                  *************
      RETURN
C
C
C
1020  FORMAT (I5)
1030  FORMAT (15A4)
1040  FORMAT (I5,3F5.0,5X,3F5.0,4I5)
1050  FORMAT (20I5)
1060  FORMAT (2I5)
1070  FORMAT (I5,F10.2,-6PF10.2,0P2F10.2,F10.2,5X,-3P2F10.3)
1080  FORMAT (5H99999)
1090  FORMAT (3I5,10X,5F10.3)
1100  FORMAT (33A4)
1110  FORMAT ('0 V OVER 20 FPS, TIDAL CYCLE',I4,' QUAL CYCLE',I4,' HYDRO
     1 CYCLE',I4,' DEPTH',E10.4,'    V',E10.4,' CHANNEL',I5)
1120  FORMAT (38H0COMPLETION OF THE HYDRAULIC PROGRAM  )
      END
      SUBROUTINE HYDPLT
C
C     ************** HYDRAULIC PROGRAM PRINTING          *************
C     ************** AND PLOTTING PROGRAM                *************
C
C     ************** BATTELLE NORTHWEST 11/9/71          *************
C     ****************************************************************
C
C
C     ************** ASSIGN THE COMMON  DATA             *************
      COMMON /TAPES/N5, N6, N20, N22, N24
      COMMON/PARAMS/IZ5, IZ6, IZ9, IZ12, IZ13
C
C     ************** CONTROL AND TITLE INFORMATION       *************
      COMMON /PRINT/ NJ, NC, NTCYC, NQCYC, DELTQ, PERIOD, ALPHA(30),
     1DEP(500), NQSWRT
      COMMON NTP, NQP, DUM(600), HP(20, 200), VOLP(20, 200), TIMEP(200), QINF(20
     1, 200), QOUP(20, 200), QP(20, 200), VP(20, 200), XX(400), YY(400), ARK(400)
     2, XYM(3, 500)
      DIMENSION ICH(6), SPACE(6), NJW(20), NCW(20), ISYM(5)
      DIMENSION CARD1(44)
      DIMENSION RUNTIT(20)
      DATA STAR/1H*/PERID/1H. /VEE/1HV/CUU/1HQ/
      DATA (SPACE(I), I=1, 6)/6*1H /
      DATA BLANK/1H /
C     **************                END                  *************
C
C
C     ************** ASK THE USER WHICH INFORMATION      *************
C     ************** HE WISHES TO PRINT AND PLOT         *************
100   CONTINUE
      READ (N5, 450, END=110) RUNTIT
      GO TO 120
110   RETURN
120   CONTINUE
      READ (N5, 510) IDAY1, IDAYL, NJP
      IF (IDAY1. LE. 0) IDAY1=1
      IF (IDAY1. LT. NQSWRT) IDAY1=NQSWRT
      IF (IDAYL. GT. NTCYC) IDAYL=NTCYC
      IF ((IDAYL-IDAY1). GT. 6) IDAYL=IDAY1+6
      IF (IDAY1. GT. IDAYL) IDAYL=IDAY1
      IF (NJP. GT. 20) WRITE (N6, 500)
      NJP=MIN0(20, NJP)
      READ (N5, 520) (NJW(I), I=1, NJP)
      READ (N5, 530) NCP
      IF (NCP. GT. 20) WRITE (N6, 540)
      NCP=MIN0(20, NCP)
      READ (N5, 520) (NCW(I), I=1, NCP)
      READ (N5, 460) NPLOTS
      WRITE (6, 470) (RUNTIT(KITE), KITE=1, 20)
      WRITE (6, 480) ALPHA
      WRITE (N6,550) IDAY1, IDAYL, NJP, (NJW(I), I=1, NJP)
      WRITE (N6,560) NCP, (NCW(I), I=1, NCP)
      IF (NPLOTS. EQ. 0) WRITE (6,490)
C     **************               END                *************
C
C
C     ************** SEARCH FOR THE DESIRED TIME INTERVAL  *************
      REWIND N24
130   READ (N24) NTP, NQP
      IF (NTP. GE. IDAY1) GO TO 140
      READ (N24)
      READ (N24)
      READ (N24)
      READ (N24)
      READ (N24)
      READ (N24)
      GO TO 130
140   CONTINUE
      DO 160 ND=IDAY1, IDAYL
      DO 150 NQC=1, NQCYC
      ILAST=(NTP-IDAY1)*NQCYC+NQP
      TIMEP(ILAST)=(FLOAT((NTP-1)*NQCYC+NQP)-0. 5)/FLOAT(NQCYC)
      CALL FIND (ILAST, NJP, DUM, NJW, HP, NJ)
      CALL FIND (ILAST, NJP, DUM, NJW, VOLP, NJ)
      CALL FIND (ILAST, NJP, DUM, NJW, QINP, NJ)
      CALL FIND (ILAST, NJP, DUM, NJW, QOUP, NJ)
      CALL FIND (ILAST, NCP, DUM, NCW, QP, NC)
      CALL FIND (ILAST, NCP, DUM, NCW, VP, NC)
      IF ((ND. EQ. IDAYL). AND. (NQC. EQ. NQCYC)) GO TO 170
      READ (N24) NTP, NQP
150   CONTINUE
      IF (ND. EQ. IDAYL) GO TO 170
160   CONTINUE
C     **************               END                *************
C
C
C     ************** WRITE OUT THE JUNCTION DATA TO PRINTER ************
170   CONTINUE
      IWHOLE=NJP/3
      IPART=NJP-IWHOLE*3
      IF (IWHOLE. EQ. 0) GO TO 210
      DO 200 I=1, IWHOLE
      IL=(I-1)*3
      WRITE (6,470) (RUNTIT(KITE), KITE=1, 20)
      WRITE (6,480) ALPHA
      DO 180 IK=1, 3
180   ICH(IK)=NJW(IL+IK)
      WRITE (N6,570) (SPACE(L), ICH(L), L=1, 3)
      WRITE (N6,580) (SPACE(L), L=1, 3)
      WRITE (N6,590) (SPACE(L), L=1, 3)
      DO 190 IDAY=IDAY1, IDAYL
      IL1=IL+1
      IL3=IL+3
      ID=(IDAY-IDAY1)*NOCYC+1
      IDL=ID-1+NOCYC
      WRITE (N6,600) IDAY
      WRITE (N6,610) (TIMEP(L),(HP(I1,L),VOLP(I1,L),QINP(I1,L),QOUP(I1,L
     1),I1=IL1,IL3),L=ID,IDL)
190   CONTINUE
200   CONTINUE
      IF (IPART.LE.0) GO TO 260
210   ILL=IWHOLE*3+IPART
      IL1=IWHOLE*3+1
      DO 220 I=IL1,ILL
      J=I-IL1+1
220   ICH(J)=NJW(I)
      WRITE (6,470) (RUNTIT(KITE),KITE=1,20)
      WRITE (6,480) ALPHA
      WRITE (N6,570) (SPACE(L),ICH(L),L=1,IPART)
      WRITE (N6,580) (SPACE(L),L=1,IPART)
      WRITE (N6,590) (SPACE(L),L=1,IPART)
      DO 250 IDAY=IDAY1,IDAYL
      IL1=IWHOLE*3+1
      ILL=IWHOLE*3+IPART
      ID=(IDAY-IDAY1)*NOCYC+1
      IDL=ID-1+NOCYC
      WRITE (N6,600) IDAY
      GO TO (230,240), IPART
230   WRITE (N6,620) (TIMEP(L),HP(IL1,L),VOLP(IL1,L),QINP(IL1,L),QOUP(IL
     11,L),L=ID,IDL)
      GO TO 250
240   WRITE (N6,630) (TIMEP(L),(HP(I1,L),VOLP(I1,L),QINP(I1,L),QOUP(I1,L
     1),I1=IL1,ILL),L=ID,IDL)
250   CONTINUE
260   CONTINUE
C     **************              END                   *************
C
C
C     ************* WRITE OUT THE CHANNEL DATA TO THE PRINTER *********
      IWHOLE=NCP/6
      IPART=NCP-IWHOLE*6
      IF (IWHOLE.EQ.0) GO TO 300
      DO 290 I=1,IWHOLE
      WRITE (6,470) (RUNTIT(KITE),KITE=1,20)
      WRITE (6,480) ALPHA
      IL=(I-1)*6
      DO 270 IK=1,6
270   ICH(IK)=NCW(IL+IK)
      WRITE (N6,640) (SPACE(L),ICH(L),L=1,6)
      WRITE (N6,650) (SPACE(L),L=1,6)
      WRITE (N6,660) (SPACE(L),L=1,6)
      DO 280 IDAY=IDAY1,IDAYL
      IL1=IL+1
      IL3=IL+6
      ID=(IDAY-IDAY1)*NQCYC+1
      IDL=ID-1+NQCYC
      WRITE (N6,600) IDAY
      WRITE (N6,670) (TIMEP(L),(QP(I1,L),VP(I1,L),I1=IL1,IL3),L=ID,IDL)
280   CONTINUE
290   CONTINUE
      IF (IPART.LE.0) GO TO 380
300   ILL=IWHOLE*6+IPART
      IL1=IWHOLE*6+1
      DO 310 I=IL1,ILL
      J=I-IL1+1
310   ICH(J)=NCH(I)
      WRITE (6,470) (RUNTIT(KITE),KITE=1,20)
      WRITE (6,480) ALPHA
      WRITE (N6,640) (SPACE(L),ICH(L),L=1,IPART)
      WRITE (N6,650) (SPACE(L),L=1,IPART)
      WRITE (N6,660) (SPACE(L),L=1,IPART)
      DO 370 IDAY=IDAY1,IDAYL
      ID=(IDAY-IDAY1)*NQCYC+1
      IDL=ID-1+NQCYC
      WRITE (N6,680) IDAY
      GO TO (320,330,340,350,360), IPART
320   CONTINUE
      WRITE (N6,680) (TIMEP(L),(QP(I1,L),VP(I1,L),I1=IL1,ILL),L=ID,IDL)
      GO TO 370
330   CONTINUE
      WRITE (N6,690) (TIMEP(L),(QP(I1,L),VP(I1,L),I1=IL1,ILL),L=ID,IDL)
      GO TO 370
340   CONTINUE
      WRITE (N6,700) (TIMEP(L),(QP(I1,L),VP(I1,L),I1=IL1,ILL),L=ID,IDL)
      GO TO 370
350   CONTINUE
      WRITE (N6,710) (TIMEP(L),(QP(I1,L),VP(I1,L),I1=IL1,ILL),L=ID,IDL)
      GO TO 370
360   CONTINUE
      WRITE (N6,720) (TIMEP(L),(QP(I1,L),VP(I1,L),I1=IL1,ILL),L=ID,IDL)
370   CONTINUE
380   CONTINUE
C     **************              END                    *************
C
C
C     ************** CALCULATE THE NUMBER OF POINTS TO BE PLOTTED ******
      IF (NPLOTS.EQ.0) GO TO 100
      NPOINT=(IDAYL-IDAY1+1)*NQCYC
C     **************            END                      *************
C
C     ************** SET UP THE SYMBOL PRIORITIES FOR PICTUR ***********
      DO 390 I=1,4
390   ISYM(I)=STAR
      ISYM(5)=BLANK
C     **************            END                      *************
C
```

```
C
C     *************** SET UP THE OUTER DO LOOP FOR THE JUNCTION PLOTS ***
      DO 410 J=1,NJP
C
C     *************** SET UP THE ARRRAYS AND ALPHA NECESSARY ************
C     ***************  FOR THE PICTUR SUBROUTINE             ************
      IJUNC=NJW(J)
      HMAX=0.
      DO 400 K=1,NPOINT
      XX(K)=TIMEP(K)
      YY(K)=HP(J,K)
      HMAX=AMAX1(HMAX,ABS(HP(J,K)))
400   ARK(K)=STAR
      XX(NPOINT+1)=XX(NPOINT)
      XX(NPOINT+2)=XX(NPOINT)
      YY(NPOINT+1)=1.5*HMAX
      YY(NPOINT+2)=-1.5*HMAX
      ARK(NPOINT+1)=BLANK
      ARK(NPOINT+2)=BLANK
      NPOIN=NPOINT+2
      ENCODE (CARD1,730) IJUNC
      ENCODE (CARD1(23),740)
C     ***************                END                    *************
C
      CALL PICT0 (NPOIN,25,50,ISYM,CARD1,RUNTIT)
410   CONTINUE
C     ***************                END                    *************
C
C     *************** SET UP THE SYMBOL PRIORITIES FOR PICTUR ***********
      ISYM(1)=STAR
C     ***************                EN)                    *************
C
C
C     *************** SET UP THE OUTER DO LOOP FOR THE CHANNEL PLOTS ****
      DO 440 J=1,NCP
C     *************** SEARCH FOR QMAX AND VMAX              *************
      QMAX=0.0
      DO 420 I=1,NPOINT
      QMAX=AMAX1(ABS(QP(J,I)),QMAX)
420   CONTINUE
C     ***************           END                         *************
C
C     *************** SET UP THE ARRRAYS AND ALPHA NECESSARY ************
C     ***************  FOR THE PICTUR SUBROUTINE             ************
      ICHN=NCW(J)
      DO 430 K=1,NPOINT
      YY(K)=QP(J,K)/1000.
      ARK(K)=STAR
430   CONTINUE
      YY(NPOINT+1)=1.50*QMAX/1000.
      YY(NPOINT+2)=-1.50*QMAX/1000.
      ENCODE (CARD1,750) ICHN
      ENCODE (CARD1(23),760)
C
C     **************              END                    *************
C
      CALL PICT0 (NPOIN,25,50,ISYM,CARD1,RUNTIT)
440   CONTINUE
C     **************           END                       *************
C
C
      GO TO 100
C     **************              END                    *************
C
C
C
450   FORMAT (20A4)
460   FORMAT (I5)
470   FORMAT (1H1,25X,20A4)
480   FORMAT (1H0,15A4,20X,20HBATTELLE NORTHWEST  ,/1X,15A4,19X,21H RICH
     1LAND, WASHINGTON,/,81X,20HEXPLORE-1 CODE       ,/81X,20HHYDRODYNAMI
     2C MODEL  ,/)
490   FORMAT (' AS REQUESTED THE PLOTS WILL BE SUPRESSED.')
500   FORMAT (' YOU CANNOT MONITOR MORE THAN 20 NODES AT ONE TIME '/)
510   FORMAT (2I10,/I10)
520   FORMAT (20I4)
530   FORMAT (I10)
540   FORMAT (' YOU CANNOT MONITOR MORE THAN 20 CHANNELS AT ONE TIME '/)
550   FORMAT (1H0,'FOR WHAT SPAN OF DAYS DO YOU WISH LINEPRINTER AND PLO
     1T INFORMATION'/' I WISH TO LOOK AT THE DATA STARTING WITH DAY',I5,
     2' AND ENDING WITH DAY',I5,//' HOW MANY NODAL POINTS DO YOU WISH TO
     3 MONITOR'/' I WISH TO MONITOR ',I5,' NODES'//' FOR WHICH NODES DO
     4 YOU WISH LINEPRINTER AND PLOT INFORMATION'/' I WISH TO MONITOR TH
     5E FOLLOWING NODES '/20I5,/20I5)
560   FORMAT (//,' HOW MANY CHANNELS DO YOU WISH TO MONITOR '/' I WISH T
     1O MONITOR ',I5,' CHANNELS '//' FOR WHICH CHANNELS DO YOU WISH LINE
     2PRINTER AND PLOT INFORMATION '/' I DESIRE PLOT AND LINEPRINTER INF
     3ORMATION FOR THE FOLLOWING CHANNELS '/20I5/20I5)
570   FORMAT (1H0,34X,A1,8HJUNCTION,I4,A1,3X,24X,8HJUNCTION,I4,A1,3X,24X
     1,8HJUNCTION,I4)
580   FORMAT (7X,A1,4HTIME,36H     HEAD   VOLUME   INFLOW  OUTFLOW,A1,3X
     1,36H     HEAD   VOLUME   INFLOW  OUTFLOW,A1,3X,36H     HEAD   VOLU
     2ME   INFLOW  OUTFLOW)
590   FORMAT (5X,A1,6H(DAYS),36H      (FT)  (FT**3)    (CFS)    (CFS),A1,
     13X,36H      (FT)  (FT**3)    (CFS)    (CFS),A1,3X,36H      (FT)  (FT
     2**3)    (CFS)    (CFS))
600   FORMAT (12H DAY NUMBER ,I4)
610   FORMAT (E12.4,4E9.3,4X,4E9.3,4X,4E9.3)
620   FORMAT (E12.4,4E9.3)
630   FORMAT (E12.4,4E9.3,4X,4E9.3)
640   FORMAT (1H0,16X,A1,8HCHANNEL ,I4,A1,7X,8HCHANNEL ,I4,A1,7X,8HCHANN
     1EL ,I4,A1,7X,8HCHANNEL ,I4,A1,7X,8HCHANNEL ,I4,A1,7X,8HCHANNEL ,I4
     2)
650   FORMAT (7X,A1,4HTIME,18H     FLOW VELOCITY,A1,19H      FLOW VELOCI
     1TY,A1,19H       FLOW VELOCITY,A1,19H       FLOW VELOCITY,A1,19H
     2 FLOW VELOCITY,A1,19H       FLOW VELOCITY)
660   FORMAT (5X,A1,6H(DAYS),18H    (CFS) (FT/SEC),A1,19H     (CFS) (FT/
     1SEC),A1,19H     (CFS) (FT/SEC),A1,19H     (CFS) (FT/SEC),A1,19H
     2  (CFS) (FT/SEC),A1,19H     (CFS) (FT/SEC))
670   FORMAT (E12.4,2E9.3,2X,2E9.3,2X,2E9.3,2X,2E9.3,2X,2E9.3,2X,2E9.3)
680   FORMAT (E12.4,2E9.3)
690   FORMAT (E12.4,2E9.3,2X,2E9.3)
700   FORMAT (E12.4,2E9.3,2X,2E9.3,2X,2E9.3)
710   FORMAT (E12.4,2E9.3,2X,2E9.3,2X,2E9.3,2X,2E9.3)
720   FORMAT (E12.4,2E9.3,2X,2E9.3,2X,2E9.3,2X,2E9.3,2X,2E9.3)
730   FORMAT (' PLOT OF THE HEAD VERSUS TIME CURVE FOR JUNCTION ',I4)
740   FORMAT (' (HEAD IS IN FEET AND THE TIME IS IN DAYS) ')
750   FORMAT (' PLOT OF THE FLOW VERSUS TIME CURVE FOR CHANNEL',I4)
760   FORMAT (' (FLOW IN (THOUSANDS OF CFS)  AND TIME IN (DAYS)')
      END
      SUBROUTINE GENFUN (Z1,Z2,IY,IX,Z3)
C
C     ************** BATTELLE NORTHWEST 11/9/71           *************
C     ***************************************************************
C
C
C     ************** ASSIGN THE COMMON  DATA              *************
      COMMON /TAPES/N5,N6,N20,N22,N24
      COMMON/PARAMS/IZ5,IZ6,IZ9,IZ12,IZ13
C
C     ************** CONTROL AND TITLE INFORMATION        *************
      COMMON /PRINT/ NJ,NC,NTCYC,N(CYC,DELTQ,PERIOD,ALPHA(30),
     1DEP(500),NQSWRT
      COMMON/QUAL/NCHAN(500,6),AS(500),LEN(600),NJUNC(600,2)
      COMMON QINT,DELT,WIND,WDIR,NJSW,NJGW,NHCYC,NT,ICYC,NCYC,W,
     1NEXIT,JSW(20),JGW(20),A0(3,20,10)
C
C     ************** JUNCTION INFORMATION                 *************
C
      COMMON H(500),HN(500),HT(500),HBAR(500),HAVE(500),
     1IPOINT(500,6),VOL(500),X(500),Y(500),QIN(500),QOU(500),
     2QINST(20),QINBAR(500),QOUBAR(500)
C
C     ************** CHANNEL INFORMATION                  *************
C
      COMMON B(600),R(600),A(600),AT(600),AK(600),Q(600),QBAR(600),
     1QAVE(600),V(600),VT(600),VBAR(600),FWIND(600),NTEMP(6),
     2NCLOS(600)
C
      REAL LEN
C     **************                 END                  *************
C     ***************************************************************
C
C
      IF (IY.EQ.2) GO TO 200
C
C     **************  CONTROLLED NODE FUNCTIONS DESIRED    *************
      IJK=JGW(IX)
      GO TO (100,120,130,170,140,140), IJK
C
C     **************    WIER FORMULA DESIRED              *************
100   CONTINUE
      Z2=0.
      CON=Z3/AS(IX)
      DHL=0.
      DO 110 ICT=1,12
      DH=(Z2+DHL)/2.
      DHL=Z2
      Z2=-CON*Z1
      H2=H(IX)+DH/2.-A0(1,IX,2)
      IF (H2.LE.0) GO TO 110
      Z2=CON*(-Z1-A0(1,IX,1)*(H2)**A0(1,IX,3))
110   CONTINUE
      RETURN
C     **************               END                  **************
C
C     **************   TIDAL CONTROLLED NODE            **************
120   Z2=A0(1,IX,1)+A0(1,IX,2)*SIN(W*Z1)+A0(1,IX,3)*SIN(2.*W*Z1)+A0(1,IX
     1,4)*SIN(3.*W*Z1)+A0(1,IX,5)*COS(W*Z1)+A0(1,IX,6)*COS(2.*W*Z1)+A0(1
     2,IX,7)*COS(3.*W*Z1)
      RETURN
C     **************               END                  **************
C
C     **************            Q VS H NODE              *************
130   TX=Z1
      GO TO 150
C     **************            END                     **************
C     **************      HVS T AND Q VS T NODES        **************
140   CONTINUE
      TX=Z1/3600.
150   I1=1
      I2=IX
      IRETUR=1
      GO TO 220
160   CONTINUE
      Z2=ZZ
      RETURN
C     **************              END                   **************
C
C
C     **************   THIS IS THE H VS T AND Q VS T NODE  **************
170   CONTINUE
      TX=Z3/3600.
      I1=1
      I2=IX
      IRETUR=2
      GO TO 220
180   CONTINUE
      Z2=ZZ
      I1=2
      IRETUR=3
      GO TO 220.
190   CONTINUE
      Z1=ZZ
      RETURN
C     **************             END                    **************
C
C
C     **************  GENERATE THE HYDROGRAPH OUTPUTS   **************
200   CONTINUE
      TX=Z1/3600.
      I1=3
      I2=IX
      IRETUR=4
      GO TO 220
210   CONTINUE
      Z2=ZZ
      RETURN
C     **************                END                  *************
C
C
C     ************** GENERATE THE FUNCTION               *************
220   CONTINUE
      ZZ=A0(I1, I2, 1)+A0(I1, I2, 2)*TX+A0(I1, I2, 3)*TX**2+A0(I1, I2, 4)*TX**3+
     1A0(I1, I2, 5)*TX**4+A0(I1, I2, 6)*TX**5+A0(I1, I2, 7)*TX**6+A0(I1, I2, 8)*
     2TX**7+A0(I1, I2, 9)*TX**8+A0(I1, I2, 10)*TX**9
      GO TO (160, 180, 190, 210), IRETUR
C     **************                  END                *************
C
      END
      SUBROUTINE PICT0 (N,M,MCOL,ISYM,CARD1,RUNTIT)
C     PROGRAMMED BY JE SCHLOSSER  1965  MODIFIED BY CA OSTER  1966
C     PRESENTS A PICTURE OF DATA ON PRINTED OUTPUT, TWO OPTIONS BEING
C     AVAILABLE
C        1   MCOL POSITIVE
C        2   MCOL NEGATIVE, IN WHICH CASE XINCREMENTS ARE TAKEN AS EQUAL
C            TO Y INCREMENTS AS DETERMINED BY M
C
C     DICTIONARY
C
C        VARIABLE   DEFINITION
C          N        NUMBER OF POINTS TO PLOT      (MAXIMUM OF 500)
C          M        MAXIMUM NUMBER OF LINES
C          MCOL     MAXIMUM NUMBER OF COLUMNS
C
C         XX(I)     X COORDINATE FOR ITH POINT
C         YY(I)     Y COORDINATE FOR ITH POINT
C         ARK(I)    MARKER FOR ITH POINT
C         ISYM(I)   PRIORITY DESIGNATOR FOR MARKER USED ON I-TH POINT
C                         (LOWER SUBSCRIPT INDICATES HIGHER PRIORITY)
C
C
C     ************** BATTELLE NORTHWEST 11/[illegible]/71          *************
C     ****************************************************************
C
C
C     ************** ASSIGN THE COMMON  DATA                 *************
      COMMON /TAPES/N5,N6,N20,N22,N24
      COMMON/PARAMS/I25,I26,I29,I212,I213
C
C     ************** CONTROL AND TITLE INFORMATION          *************
     1DEP(500),NOSWRT
      COMMON NTP,NOP,DUM(600),HP(20,200),VOLP(20,200),TIMEP(200),QINP(20
     1,200),QOUP(20,200),UP(20,200),VP(20,200),XX(400),YY(400),ARK(400)
     2,XYM(3,500)
      DIMENSION IXYM(3,500)
      EQUIVALENCE (IXYM,XYM)
      DIMENSION PX(6),ALF(107),ILF(107),ISYM(5)
      DIMENSION CARD1(44)
C     DICTIONARY
C
C        VARIABLE   DEFINITION
C          N        NUMBER OF POINTS TO PLOT      (MAXIMUM OF 500)
C          M        MAXIMUM NUMBER OF LINES
C          MCOL     MAXIMUM NUMBER OF COLUMNS
C
C         XX(I)     X COORDINATE FOR ITH POINT
C         YY(I)     Y COORDINATE FOR ITH POINT
C         ARK(I)    MARKER FOR ITH POINT
C         ISYM(I)   PRIORITY DESIGNATOR FOR MARKER USED ON I-TH POINT
C                         (LOWER SUBSCRIPT INDICATES HIGHER PRIORITY)
```

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C
C
C     *************** BATTELLE NORTHWEST 11/9/71             **************
C     ****************************************************************************
C
C
C     *************** ASSIGN THE COMMON  DATA                **************
      COMMON /TAPES/N5,N6,N20,N22,N24
      COMMON/PARAMS/IZ5,IZ6,IZ9,IZ12,IZ13
C
C     ************** CONTROL AND TITLE INFORMATION           **************
      COMMON /PRINT/ NJ,NC,NTCYC,NOCYC,DELTO,PERIOD,ALFHA(30),
     1DEP(500),NQSWRT
      COMMON NTP,NQP,DUM(600),HP(20,200),VOLP(20,200),TIMEP(200),QINP(20
     1,200),QOUP(20,200),QP(20,200),VP(20,200),XX(400),YY(400),ARK(400)
     2,XYM(3,500)
      DIMENSION IXYM(3,500)
      EQUIVALENCE (IXYM,XYM)
      DIMENSION PX(6),ALF(107),ILF(107),ISYM(5)
      DIMENSION CARD1(44)
      DIMENSION RUNTIT(20)
      EQUIVALENCE (ILF,ALF),(BLANK,LANKBA)
C
      DATA BLANK/1H  /
C
      EXTERNAL SORDER
      KILL=0
      N=MAX0(MIN0(500,N),2)
      XYM(1,2)=1.01
      XYM(2,2)=1.01
      XYM(3,2)=BLANK
      XMIN=1.0E37
      XMAX=-1.0E37
      DO 100 I=1,N
      XYM(1,I)=XX(I)
      XYM(2,I)=YY(I)
      XYM(3,I)=ARK(I)
      XMIN=AMIN1(XMIN,XYM(1,I))
      XMAX=AMAX1(XMAX,XYM(1,I))
 100  CONTINUE
      CALL SORT (XYM,N,3,SORDER)
      YMIN=XYM(2,N)
      YMAX=XYM(2,1)
      DYLOG=ALOG10((YMAX-YMIN)/FLOAT(M)*1.0E5)
      APROX=DYLOG-AINT(DYLOG)
      DO 110 I=2,10
      FI=I
      IF (APROX-ALOG10(FI)) 120,120,110
 110  CONTINUE
 120  EXACT=FI*10.0**(INT(DYLOG)-5)
 130  IF (MCOL) 200,140,140
 140  DXLOG=ALOG10((XMAX-XMIN)/FLOAT(MCOL/2)*1.0E5)
```

```
      XAPROX=DXLOG-AINT(DXLOG)
      IF (XAPROX-.3010) 150,150,160
150   XEXACT=2.0*10.0**(INT(DXLOG)-5)
      GO TO 190
160   IF (XAPROX-.6990) 170,170,180
170   XEXACT=5.0*10.0**(INT(DXLOG)-5)
      GO TO 190
180   XEXACT=10.0**(INT(DXLOG)-4)
190   CONTINUE
      XACT=XEXACT/2.0
      GO TO 210
200   XACT=EXACT/2.0
210   TENX=20.0*XACT
      TENE=10.0*EXACT
      MAXYI=(YMAX/TENE)+(0.5+SIGN(0.5,YMAX))
      MAXXI=(XMAX/TENX)+(0.5+SIGN(0.5,XMAX))
      MINYI=(YMIN/TENE)-(0.5+SIGN(0.5,-YMIN))
      MINXI=(XMIN/TENX)-(0.5+SIGN(0.5,-XMIN))
      YFIRST=TENE*FLOAT(MAXYI)
      XFIRST=TENX*FLOAT(MINXI)
      LINES=10*(MAXYI-MINYI)+1
      KOLS=20*(MAXXI-MINXI)
      IF (KOLS-500) 230,230,220
220   WRITE (6,530) KOLS
      KOLS=500
230   IF (LINES-401) 250,250,240
240   WRITE (6,540)
      RETURN
250   CONTINUE
      KILL=KILL+1
      IF (KILL.GT.500) GO TO 260
      IF (KOLS.GE.75) GO TO 260
      MCOL=MCOL+1
      GO TO 130
260   LEAF=(KOLS+99)/100
      IF (LEAF.LE.1) GO TO 270
      MCOL=MCOL-1
      GO TO 130
270   DO 450 L=1,LEAF
      DO 280 I=1,6
      PX(I)=5.*TENX*FLOAT(L-1)+TENX*FLOAT(I-1)+XFIRST
280   CONTINUE
      WRITE (6,470) (RUNTIT(KITE),KITE=1,20)
      WRITE (6,460) ALPHA
      WRITE (6,480) (CARD1(ISTAT),ISTAT=1,44)
      WRITE (6,520) PX
      WRITE (6,510)
      DEX=XACT/2.0
      DEL=EXACT/2.0
      DDD=DEX+2.0*XACT
      J=1
      DO 440 I=1,LINES
      YPLOT=YFIRST-EXACT+FLOAT(I-1)
      DO 290 JKL=1,107
290   ALF(JKL)=BLANK
300   IF (J-N) 310,310,400
310   IF (XYM(1,J)-PX(1)) 390,320,320
320   CONTINUE
      IF (XYM(2,J)-(YPLOT+DEL)) 330,330,400
330   IF (XYM(2,J)-(YPLOT-DEL)) 400,340,340
340   CONTINUE
      IF (XYM(1,J)-PX(6)-DDD) 350,350,390
350   CONTINUE
      KOL=INT((XYM(1,J)+DEX-PX(1))/XACT)+4
      IF ((KOL.GT.107).OR.(KOL.LT.1)) GO TO 390
      IXYM3J=IXYM(3,J)
      ILFKOL=ILF(KOL)
      IF (ILFKOL.EQ.LANKBA) GO TO 380
      ISYM1=0
      ISYM2=0
      DO 360 IIYY=1,5
      IF (ILFKOL.EQ.ISYM(IIYY)) ISYM1=IIYY
      IF (IXYM3J.EQ.ISYM(IIYY)) ISYM2=IIYY
360   CONTINUE
      ISYMM=MIN0(ISYM1,ISYM2)
      IF (ISYMM) 390,390,370
370   ILF(KOL)=ISYM(ISYMM)
      GO TO 390
380   ALF(KOL)=XYM(3,J)
390   J=J+1
      GO TO 300
400   CONTINUE
      IF (MOD(I-1,10).NE.0) GO TO 410
      WRITE (6,490) YPLOT,ALF
      GO TO 430
410   IF (MOD(I-1,5).NE.0) GO TO 420
      WRITE (6,550) ALF
      GO TO 430
420   WRITE (6,500) ALF
430   CONTINUE
440   CONTINUE
      WRITE (6,510)
      WRITE (6,520) PX
450   CONTINUE
      RETURN
C
C
C
460   FORMAT (1H0,15A4,20X,20HBATTELLE NORTHWEST  ,/1X,15A4,19X,21H RICH
     1LAND, WASHINGTON,/,81X,20HEXPLORE-1 CODE      ,/81X,20HHYDRODYNAMI
     2C MODEL  ,/)
470   FORMAT (1H1,25X,20A4)
480   FORMAT (1H0,//22A6,/22A6///)
490   FORMAT (1XF9.3,2H *107A1,1H*)
```

```
500   FORMAT (11X1HI107A1,1HI)
510   FORMAT (1H014X1H*5(20H - - - - + - - - - - *)/1H )
520   FORMAT (11XF7.2,5(13XF7.2))
530   FORMAT (48H0ONLY THE FIRST 500 COLUMNS OF A PLOT REQUIRING I3,25H
     1COLUMNS WILL BE PRINTED.)
540   FORMAT (69H0NOBODY IN THEIR RIGHT MIND WOULD WANT A PLOT OF MORE T
     1HAN 400 LINES.)
550   FORMAT (11X1H+107A1,1H+)
      END
      SUBROUTINE FIND (ILAST,NJP,DUM,NJW,HP,NJ)
      COMMON /TAPES/N5,N6,N20,N22,N24
      DIMENSION DUM(600),NJW(20),HP(20,200)
      READ (N24) (DUM(I),I=1,NJ)
      DO 100 I=1,NJP
      NP=NJW(I)
      HP(I,ILAST)=DUM(NP)
100   CONTINUE
      RETURN
      END
```

```
C     ************** PROGRAM TO REPRINT PREVIOUSLY WRITTEN *************RPT   1
C     ************** HYDRAULIC DATA FROM THE HYDRAULIC     *************RPT   2
C     **************        OUTPUT TAPE                    *************RPT   3
C     *****************************************************************RPT   4
C                                                                      RPT   5
C                                                                      RPT  19
C                                                                      RPT  20
C     ************** ASSIGN THE COMMON  DATA               *************RPT  21
      COMMON /TAPES/N5,N6,N20,N22,N24                                  RPT  22
      COMMON/PARAMS/IZ5,IZ6,IZ9,IZ12,IZ13
C                                                                      RPT  23
C     ************** CONTROL AND TITLE INFORMATION         *************RPT  24
      COMMON /PRINT/ NJ,NC,NTCYC,NQCYC,DELTQ,PERIOD,TZERO,ALPHA(30),   RPT  25
     1DEP(500),NQSWRT                                                  RPT  26
      COMMON /QUAL/ NCHAN(500,6),   AS(500),LEN(600),NJUNC(600,2)      RPT  27
      COMMON @INT,DELT,WIND,WDIR,NJSW,NJGW,NHCYC,NT,ICYC,NCYC,W,       RPT  28
     1NEXIT,JSW(20),   JGW(20),   AG(3,20,10)                          RPT  29
C                                                                      RPT  30
C     ************** JUNCTION INFORMATION                  *************RPT  31
      COMMON H(500),HN(500),HT(500),HBAR(500),HAVE(500),               RPT  32
     1IPOINT(500,6),   VOL(500),X(500),Y(500),QIN(500),QOU(500),       RPT  33
     2QINST(20),   QINBAR(500),QOUBAR(500)                             RPT  34
C                                                                      RPT  35
C     ************** CHANNEL INFORMATION                   *************RPT  36
      COMMON B(600),R(600),A(600),AT(600),AK(600),Q(600),QBAR(600),    RPT  37
     1QAVE(600),V(600),VT(600),VBAR(600),FWIND(600),NTEMP(6),          RPT  38
     2NCLOS(600)                                                       RPT  39
      COMMON NTRIB,TRBDEP(50),ITRIB(50,2)                              RPT  40
C                                                                      RPT  41
      REAL LEN                                                         RPT  42
      INTEGER FTBX(40)                                                 RPT  43
C                                                                      RPT  44
      IZ5=500
      IZ6=6
      IZ9=600
      IZ12=20
      IZ13=20
C
C     *************  SET UP THE DRUM FOR AN INTERMEDIATE   *************RPT  45
C     *************  OUTPUT DEVICE                         *************RPT  46
      CALL SETDR (4,960000,110000,FTBX(8))                             RPT  47
C     *************                END                     *************RPT  48
C     *************  ASSIGN THE UNIT NUMBERS AND REWIND    *************RPT  49
      N5=5                                                             RPT  50
      N6=6                                                             RPT  51
      N20=2                                                            RPT  52
      N24=4                                                            RPT  53
      REWIND N20                                                       RPT  54
      REWIND N24                                                       RPT  55
C     *************                END                     *************RPT  56
      READ (N20) (ALPHA(I),I=1,30),NJ,NC,NQCYC,DELTQ,NTCYC,NQSWRT,NJGW,ERPT  57
     1VAP,((NCHAN(J,K),K=1,IZ6),DEP(J),AS(J),J=1,NJ),(LEN(N),(NJUNC(N,K)RPT   58
     2,K=1,2),N=1,NC),PERIOD,(JGW(I),I=1,NJGW)                          RPT   59
      READ (N20) ((IPOINT(J,K),K=1,IZ6),J=1,NJ),TZERO                   RPT   60
      DO 100 ND=NQSWRT,NTCYC                                            RPT   61
      DO 100 NQQ=1,NQCYC                                                RPT   62
      READ (N20) NT,NQ,(HBAR(J),VOL(J),QINBAR(J),QOUBAR(J),J=1,NJ),(QBARRPT   63
     1(N),VBAR(N),N=1,NC)                                               RPT   64
C                                                                       RPT   65
      WRITE (N24) NT,NQ                                                 RPT   66
      WRITE (N24) (HBAR(J),J=1,NJ)                                      RPT   67
      WRITE (N24) (VOL(J),J=1,NJ)                                       RPT   68
      WRITE (N24) (QINBAR(J),J=1,NJ)                                    RPT   69
      WRITE (N24) (QOUBAR(J),J=1,NJ)                                    RPT   70
      WRITE (N24) (QBAR(N),N=1,NC)                                      RPT   71
      WRITE (N24) (VBAR(N),N=1,NC)                                      RPT   72
  100 CONTINUE                                                          RPT   73
      REWIND N20                                                        RPT   74
      REWIND N24                                                        RPT   75
      CALL HYDPLT                                                       RPT   76
C     **************                 END                  **************RPT   77
      STOP                                                              RPT   78
      END                                                               RPT   79-
```

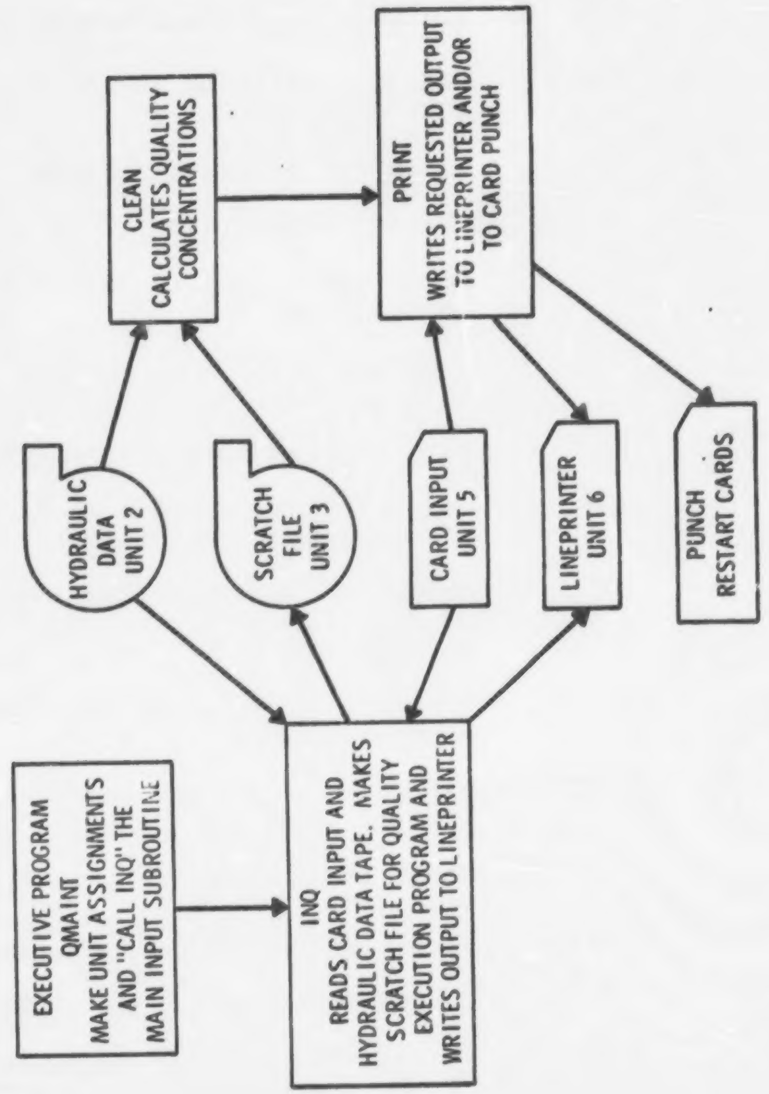
EXECUTIVE PROGRAM
QMAINT
MAKE UNIT ASSIGNMENTS
AND "CALL INQ" THE
MAIN INPUT SUBROUTINE
INQ
READS CARD INPUT AND
HYDRAULIC DATA TAPE. MAKES
SCRATCH FILE FOR QUALITY
EXECUTION PROGRAM AND
WRITES OUTPUT TO LINEPRINTER
HYDRAULIC
DATA
UNIT 2
SCRATCH
FILE
UNIT 3
CARD INPUT
UNIT 5
LINEPRINTER
UNIT 6
PUNCH
RESTART CARDS
CLEAN
CALCULATES QUALITY
CONCENTRATIONS
PRINT
WRITES REQUESTED OUTPUT
TO LINEPRINTER AND/OR
TO CARD PUNCH

FIGURE C-10. RELATIONSHIP OF QUALITY INPUT AND CALCULATION CODES

TABLE C-1

VARIABLE DEFINITION FOR HYDRAULIC CODE

Variable Name	Location	Description	Unit
A(500)	C	Channel cross-section area at start of time-step (HYDCAL,INH)	sq.ft.
AK(600)	C	Modified friction factor (HYDCAL,INH)	
ALPHA(30)	C	Title for printing (HYDCAL,INH)	
ALEN		Channel length (INH)	
ARRAY(33)		Dummy array used in printing (HYDCAL,INH)	
AREA		Computed nodal area to find initial nodal volume (HYDCAL)	
AS(500)	C	Node surface area (HYDCAL,INH)	sq.ft.
AT(600)	C	Channel cross-section at midpoint of time-step (HYDCAL,INH)	
A(3,20,10)	C	Array used to store the regression coefficients and wier constants (HYDCAL,INH)	
ATEMP(10)		Variable to pass the regression constants (INH)	
ASTERK		Variable containing asterisk (HYDCAL,INH)	
ATOT		Total surface area of receiving water (INH)	sq.ft.
ASTER		Variable containing asterisk	
A1 A2 A3 A4 A5 A6 A7		Coefficients of the expression H = A1 + A2 COS(WT) + A3COS(2WT) + A4COS(3WT) + A5SIN(WT) + A6SIN(2WT) + A7SIN(3WT) for tidal input	

TABLE C-1 (Cont'd.)

Variable Name	Location	Description	Unit
B(600)	C	Channel width (HYDCAL,INH)	ft.
BLANK		Variable containing blank (INH)	
COEF		Manning's coefficient for channel (INH)	
DEL		Temporary variable	
DELH DELHH		Increment of head of a junction for a time-step (HYDCAL)	ft.
DELMAX		Maximum difference between the calculated and stage input	ft.
DELTA		Maximum allowable difference between the calculated and input tidal stage	ft.
DELT	C	Time-step increment (HYDCAL,INH)	
DELTH		Temporary variable (HYDCAL)	
DELTQ	C	Length of quality time-step (usually an hour); (HYDCAL,INH)	sec.
DELT2		1/2 time-step increment (HYDCAL)	sec.
DELV1 DELV2		Component of velocity change during a time-step (HYDCAL)	ft./sec.
DEP(500)	C	Depth of water of a junction at zero datum (HYDCAL,INH)	ft.
DEPTH		Computed depth of node at a junction for initial volume (HYDCAL)	
DIFF		Difference between the calculated and input tidal stage	ft.
DT		Junction depth (INH)	ft.
DVOL		Volume change in a time-step (HYDCAL)	cf.
EVAP	C	Evaporation rate for whole system converted from ft/mo (HYDCAL,INH)	cfs.
EWIND(600)	C	Drag force due to wind (HYDCAL,INH)	

TABLE C-1 (Cont'd.)

Variable Name	Location	Description	Unit
FJ1		Internal variable	
FJ3		Internal variable	
H(500)	C	Head at junction at beginning of time-step (HYDCAL,INH)	ft.
HAVE(500)	C	Junction average head during a daily cycle (HYDCAL)	ft.
HBAR(500)	C	Junction average head during a quality cycle (HYDCAL)	ft.
HEAD		Distance water surface is from datum plane (INH)	ft.
HN(500)	C	Junction head at end of time-step (HYDCAL)	ft.
HOUR		Time-hours	hr.
HYDRAD(600)	C	Hydraulic radius (INH)	ft.
HT(500)	C	Junction head at end of 1/2 time-step (HYDCAL)	ft.
IDELT		Length of hydraulic cycle (integration step) (INH)	sec.
IDECK		Switch variable to request restart deck be punched (HYDCAL)	
I II IHJN IL IJK IJN		Index numbers (HYDCAL,INH)	
IFLAG		Variable to indicate small tributary channel (INH)	
IPERID		Length of tidal cycle (INH)	hrs.
IPOINT(500,6)	C	Pointer array containing node to node connections (HYDCAL,INH)	
IQINT		Length of quality cycle (INH)	sec.
IT		Iteration counter	

TABLE C-1 (Cont'd.)

Variable Name	Location	Description	Unit
ITRIB(50,2)	C	Array containing the channel numbers of the small tributary channels and also the associated junction numbers (HYDCAL,INH)	
J		Index variable (HYDCAL,INH)	
JGW(20)	C	Array indicating the type of controlled node I is (HYDCAL,INH)	
JSW(20)	C	Array of junction numbers which have time varying flow input (HYDCAL,INH)	
K		Index variable (HYDCAL,INH)	
KO		Switch to cause generation of a full tide from HHW, LLW, HLW, LHW	
LEN(600)	C	Channel length (HYDCAL,INH)	ft.
M		Index variable (HYDCAL,INH)	
MAXIT		Maximum number of iterations in tidal curve fit, usually 50	
N		Index variable (HYDCAL,INH)	
NC	C	Number of channels (HYDCAL,INH)	
NCHAN(500,6)	C	Channels associated with nodes (HYDCAL,INH)	
NCLOS(600)	C	If equal to 1 channel dry, otherwise no effect (INH,HYDCAL)	
NDRY		Number of dry junctions (HYDCAL)	
NEXIT	C	Set equal to 1 when error condition exists (HYDCAL,INH)	
NH		Node at channel end (HYDCAL)	
NHH		Hydraulic cycle counter (HYDCAL)	
NHCYC	C	Number of time-steps per quality cycle (HYDCAL,INH)	
NI		Number of tidal input values	
NINT		Number of hydraulic cycles per tidal cycle (INH)	

TABLE C-1 (Cont'd.)

Variable Name	Location	Description	Unit
NJGW	C	Number of controlled nodes (HYDCAL,INH)	
NJ	C	Number of junctions (HYDCAL,INH)	
NJ2		Temporary variables	
NJGW1		NJGW+1 (HYDCAL)	
NJSW	C	Number of junctions with time varying flow hydrograph input (HYDCAL,INH)	
NJUNC(600,2)	C	Nodes at channel ends (HYDCAL,INH)	
NL		Node at channel end (HYDCAL)	
NQ		Quality cycle counter (HYDCAL)	
NQCYC	C	Number of quality cycles per day (HYDCAL,INH)	hr.
NQSWRT	C	Number of daily cycles at which printing will start (HYDCAL,INH)	
NT	C	Daily cycle number (HYDCAL,INH)	
NTCYC	C	Number of daily cycles to be simulated (HYDCAL,INH)	
NTEMP(6)	C	Temporary array of channels entering a node (HYDCAL,INH)	
NTIMS		Number of times through drying up connection (HYDCAL)	
NTRIB	C	Number of small tributary channels (HYDCAL,INH)	
NTT		Temporary variables	
NX		Temporary variable (HYDCAL)	
N5	C	Card reader of equivalent (HYDCAL,INH)	
N6	C	Lineprinter (HYDCAL,INH)	
N7	C	(Fake printer) scratch file or permanent file (INH)	
N20	C	Hydraulic input and output file (HYDCAL,INH)	

TABLE C-1 (Cont'd.)

Variable Name	Location	Description	Unit
N22	C	Scratch file (equal to N20 in HYDCAL)	
N24	C	Scratch file	
PERIOD	C	Period in hours of daily cycle (HYDCAL,INH,TIDCF)	hr.
Q(600)	C	Channel flow (HYDCAL,INH)	cfs.
QAVE(600)	C	Daily cycle average flow (HYDCAL)	cfs.
QBAR(600)	C	Quality cycle average flow (HYDCAL)	cfs.
QF1		Temporary storage for junction inflow (INH)	cfs.
QF2		Temporary storage for junction outflow (INH)	cfs.
QIN(500)	C	Inflows to junctions (HYDCAL,INH)	cfs.
QUINBAR(500)	C	Quality cycle average junction inflow (HYDCAL)	cfs.
QINST(20)	C	Array for storing the constant inflow at junctions with flow hydrograph input (HYDCAL)	cfs.
QUINT	C	Quality time-step interval (HYDCAL,INH)	hr.
QJ2		Temporary variable (HYDCAL)	
QOU(500)	C	Outflow from junction (HYDCAL,INH)	cfs.
QOUBAR(500)	C	Quality cycle average junction outflow (HYDCAL,INH)	cfs.
R1(600)	C	Hydraulic radius (HYDCAL,INH)	ft.
RAD		Channel depth measured from datum (HYDCAL,INH)	ft.
RES		Accumulative difference between the calculated and input tidal stage	ft.
RNT		Temporary hydraulic radius at 1/2 time-step (HYDCAL)	ft.
SURF		Temporary storage for junction surface area (HYDCAL)	10^{**6}ft.^{2}

TABLE C-1 (Cont'd.)

Variable Name	Location	Description	Unit
SUM		Computed tidal stage	ft.
SUMQ		Total flow leaving junction (HYDCAL)	cfs.
SXX(10,10)		Matrix used for least square tidal fit	
SXY(10)		Vector used for least square tidal fit	
TITLE(33)		Title arrary read from cards	
T		Time counter for whole analysis (HYDCAL)	sec.
TT(50)		Time from start of storm of input for tidal condition and from hydrograph file	sec.
T2		T + 1/2 Δt (HYDCAL)	sec.
TEMP		Simplifying variable used during solution of velocities (HYDCAL)	
TF		Estimate maximum time-step for channel (INH)	sec.
TIME		Time counter for time varying input	sec.
TIM2		Time + 1/2 Δt	sec.
TRBDEP(50)	C	Small tributary channels mid-point depth measured from datum (HYDCAL,INH)	ft.
VEL		Temporary storage of velocity (INH)	ft./sec.
V(600)	C	Channel velocity at start of time-step (HYDCAL,INH)	ft./sec.
VBAR(600)	C	Average velocity during quality cycle (HYDCAL)	ft./sec.
VOL(500)	C	Nodal volume (HYDCAL,INH)	cf.
VOLUME		Initial nodal volume (HYDCAL)	cf.

TABLE C-1 (Cont'd.)

Variable Name	Location	Description	Unit
VT(600)	C	Channel velocity at 1/2 time-step (HYDCAL)	ft./sec.
V2		Velocity during a half hydraulic time-step (HYDCAL)	ft./sec.
W	C	Fundamental frequency of daily tidal variation (HYDCAL,INH)	rad./sec.
WDIR	C	Wind direction in degrees from north (HYDCAL,INH)	deg.
WIDTH		Width of channel (INH)	ft.
WIND	C	Wind force (HYDCAL,INH)	mph.
X(J)	C	X coordinate of junctions (HYDCAL,INH)	ft.
X1		Temporary storage x coordinate (INH)	ft.
XMK		Blank or asterisk depending on whether estimated maximum time-step is satisfied (INH)	
XX(10)		Vector used in least square tidal fit	
Y(J)	C	Y coordinate of junctions (HYDCAL,INH)	ft.
Y1		Temporary storage for y coordinate (INH)	ft.

Quality Input Code Description

The executive program QMAINT makes I/O device assignments and reads the pertinent geometric data from the front end of the data tape written by the hydraulic code. A flow diagram of QMAINT is shown in Figure C-11.

Subroutine INQ reads in the card input data necessary for the quality calculations. This subroutine calls ZERO and

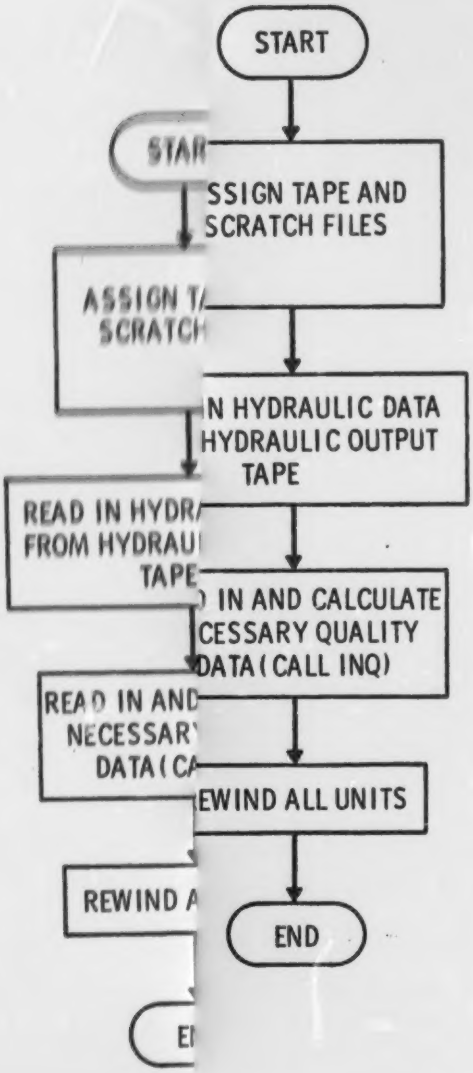
START
ASSIGN TAPE AND SCRATCH FILES
READ IN HYDRAULIC DATA FROM HYDRAULIC OUTPUT TAPE
READ IN AND CALCULATE NECESSARY QUALITY DATA (CALL INQ)
REWIND ALL UNITS
END

FIGURE C-11. FLOW CHART FOR MAIN QUALITY INPUT PROGRAM QMAINT a quality input tape with the values of all the time varying functions for each quality time step to be simulated is prepared. Figure C-12 is a flow diagram of INQ. Subroutines REGRES and PICTUR are the same as described for the hydraulic input code.

Quality Calculational Code Description

The executive program CLEAN reads in the constant input data and initializes the problem as either a new or restart case. The time varying data is then read in for each time step and the changes in concentrations due to the quality reactions are calculated for each node. The results are written out to a scratch file, after which the concentrations are transported for the time step. After all calculations have been done the results requested by the user are written to the lineprinter. A flow chart of CLEAN is shown in Figure C-13.

Subroutine REA calculates the reaeration coefficients for the node at each time step. Subroutine TRANSP solves the transport equation and adds the sources at the appropriate nodes. Subroutine TEMPER calculates the temperature correction to the reaction constants for each node and each time step. Subroutine DIFEQ solves the reactions simultaneously for the 16 concentrations using a Runge-Kutta integration scheme. Subroutine DE calls the various subroutines to calculate the derivatives required by DIFEQ. Subroutine ALG evaluates the derivatives for both phytoplankton and zooplankton. Subroutine PHO evaluates the derivatives for soluble, sedimentary and organic phosphorus. Subroutine TIN evaluates the derivatives for ammonia, nitrite, nitrate, and organic nitrogen. Subroutine SPR calculates the contribution of suspended algae to the dissolved oxygen equation. Flow charts for these subroutines are shown in Figures C-14 through C-22.

Subroutine APR calculates the contribution of attached algae and benthic plants to the dissolved oxygen equation. Subroutine BOD evaluates the derivatives for both carbonaceous and nitrogenous BOD reactions. Subroutine BEN evaluates the derivatives for the benthic BOD reaction. Subroutine TOC evaluates the derivatives for both total and refactory organic carbon. Subroutine DOX calculates the derivative for dissolved oxygen. Subroutine TOX evaluates the derivative for toxic compounds based on an n^{th} order decay rate specified by the user. Subroutine PRINT writes the output requested by the user to the lineprinter or to punched cards. Flow charts for these subroutines are given in Figures C-23 through C-29.

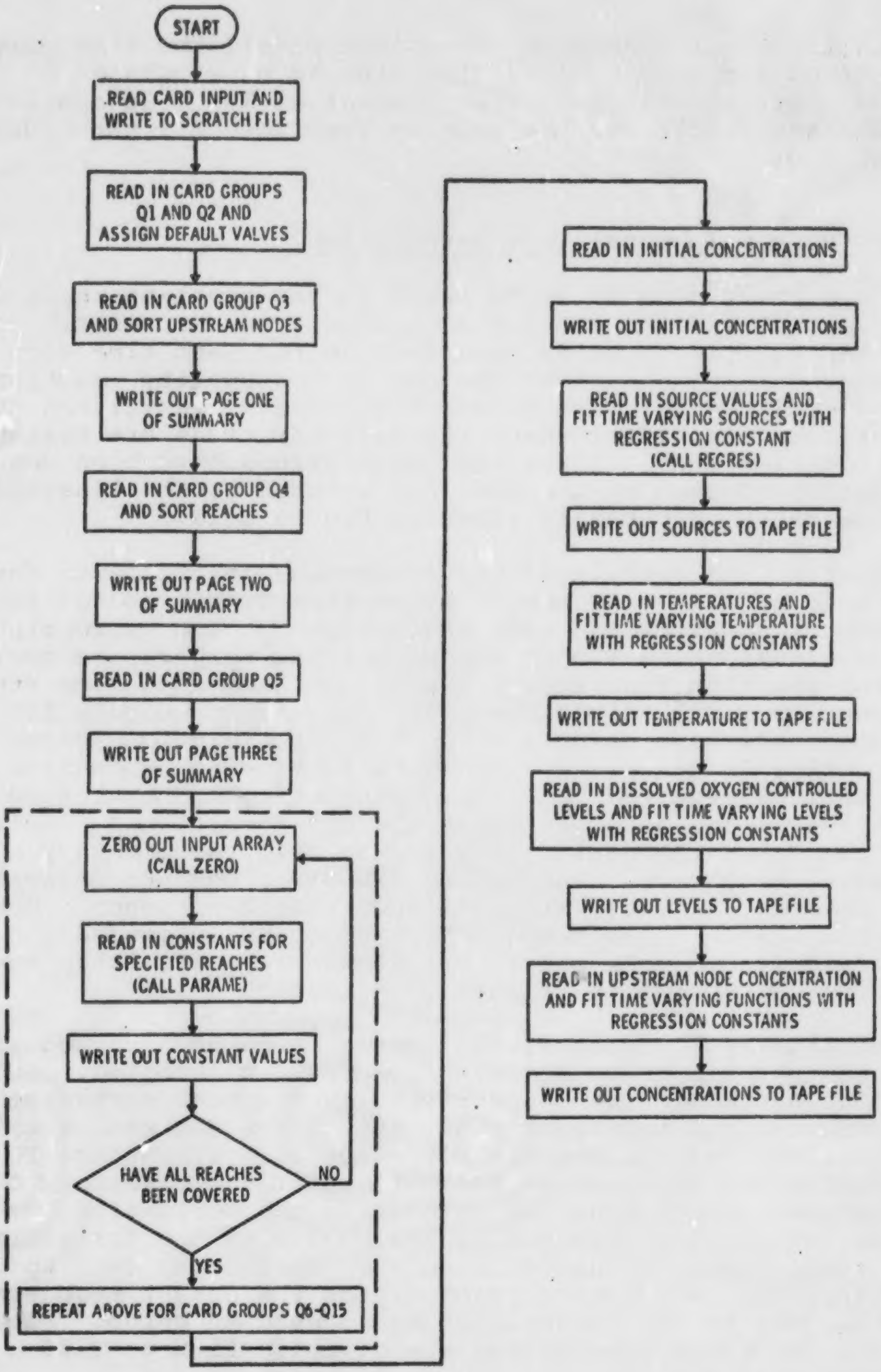
START
READ CARD INPUT AND WRITE TO SCRATCH FILE
READ IN CARD GROUPS Q1 AND Q2 AND ASSIGN DEFAULT VALVES
READ IN CARD GROUP Q3 AND SORT UPSTREAM NODES
WRITE OUT PAGE ONE OF SUMMARY
READ IN CARD GROUP Q4 AND SORT REACHES
WRITE OUT PAGE TWO OF SUMMARY
READ IN CARD GROUP Q5
WRITE OUT PAGE THREE OF SUMMARY
ZERO OUT INPUT ARRAY (CALL ZERO)
READ IN CONSTANTS FOR SPECIFIED REACHES (CALL PARAME)
WRITE OUT CONSTANT VALUES
HAVE ALL REACHES BEEN COVERED
NO
YES
REPEAT ABOVE FOR CARD GROUPS Q6-Q15
READ IN INITIAL CONCENTRATIONS
WRITE OUT INITIAL CONCENTRATIONS
READ IN SOURCE VALUES AND FIT TIME VARYING SOURCES WITH REGRESSION CONSTANT (CALL REGRES)
WRITE OUT SOURCES TO TAPE FILE
READ IN TEMPERATURES AND FIT TIME VARYING TEMPERATURE WITH REGRESSION CONSTANTS
WRITE OUT TEMPERATURE TO TAPE FILE
READ IN DISSOLVED OXYGEN CONTROLLED LEVELS AND FIT TIME VARYING LEVELS WITH REGRESSION CONSTANTS
WRITE OUT LEVELS TO TAPE FILE
READ IN UPSTREAM NODE CONCENTRATION AND FIT TIME VARYING FUNCTIONS WITH REGRESSION CONSTANTS
WRITE OUT CONCENTRATIONS TO TAPE FILE

FIGURE C-12. FLOW CHART OF QUALITY INPUT SUBROUTINE INQ

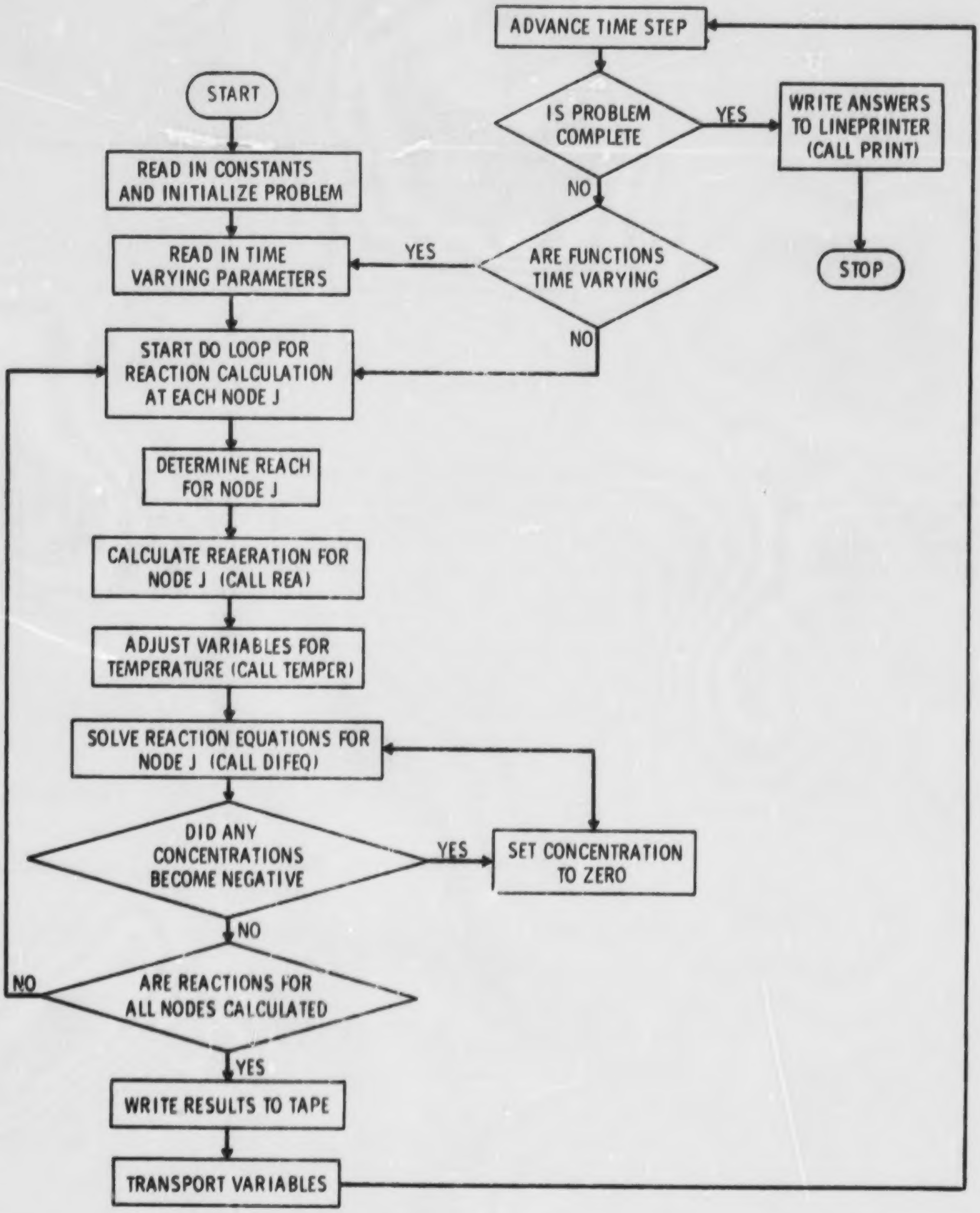
ADVANCE TIME STEP
START
IS PROBLEM COMPLETE
YES
WRITE ANSWERS TO LINEPRINTER (CALL PRINT)
READ IN CONSTANTS AND INITIALIZE PROBLEM
NO
READ IN TIME VARYING PARAMETERS
YES
ARE FUNCTIONS TIME VARYING
STOP
NO
START DO LOOP FOR REACTION CALCULATION AT EACH NODE J
DETERMINE REACH FOR NODE J
CALCULATE REAERATION FOR NODE J (CALL REA)
ADJUST VARIABLES FOR TEMPERATURE (CALL TEMPER)
SOLVE REACTION EQUATIONS FOR NODE J (CALL DIFEQ)
DID ANY CONCENTRATIONS BECOME NEGATIVE
YES
SET CONCENTRATION TO ZERO
NO
NO
ARE REACTIONS FOR ALL NODES CALCULATED
YES
WRITE RESULTS TO TAPE
TRANSPORT VARIABLES

FIGURE C-13. FLOW CHART FOR MAIN QUALITY PROGRAM CLEAN

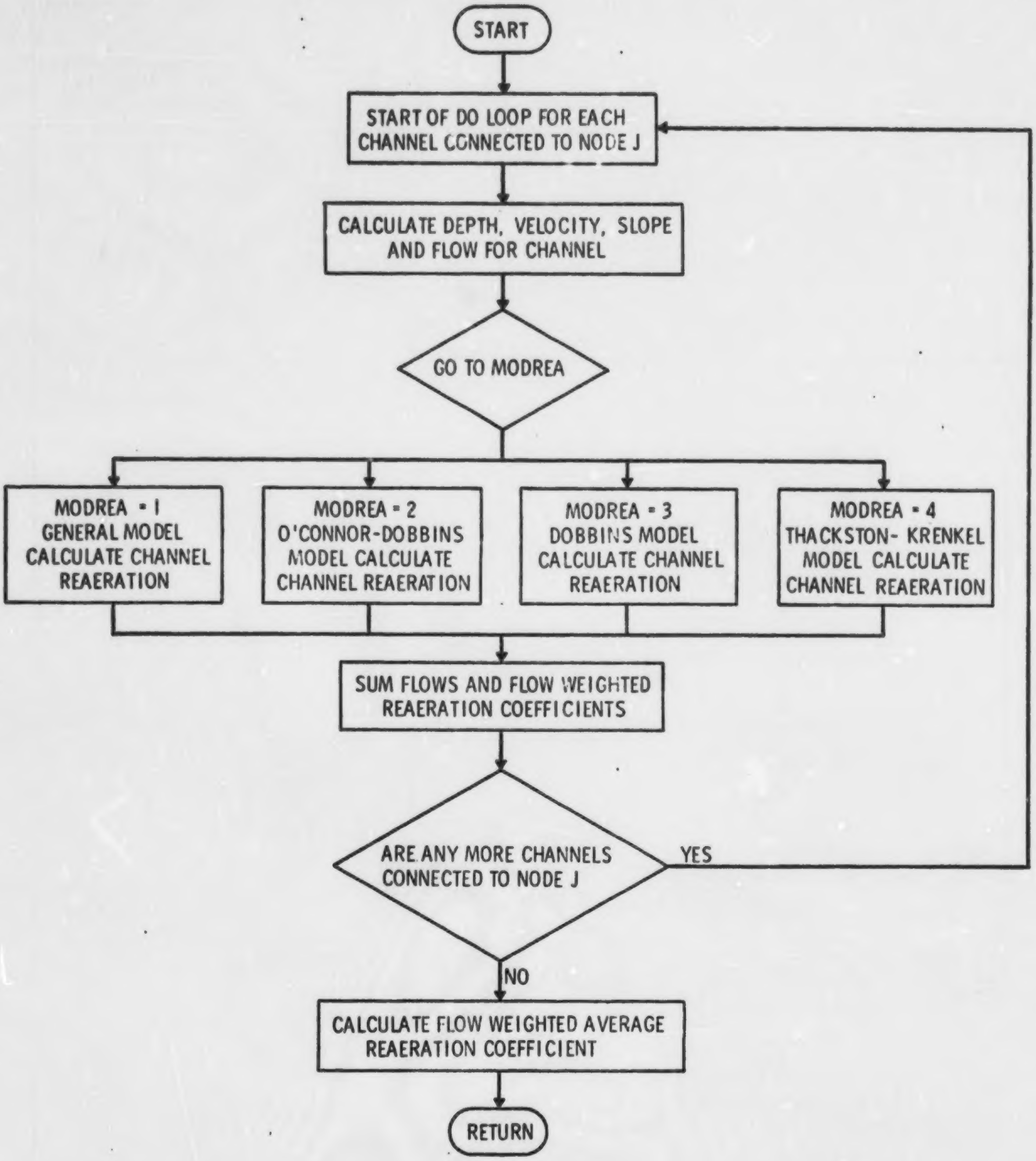
START
START OF DO LOOP FOR EACH CHANNEL CONNECTED TO NODE J
CALCULATE DEPTH, VELOCITY, SLOPE AND FLOW FOR CHANNEL
GO TO MODREA
MODREA = 1 GENERAL MODEL CALCULATE CHANNEL REAERATION
MODREA = 2 O'CONNOR-DOBBINS MODEL CALCULATE CHANNEL REAERATION
MODREA = 3 DOBBINS MODEL CALCULATE CHANNEL REAERATION
MODREA = 4 THACKSTON- KRENKEL MODEL CALCULATE CHANNEL REAERATION
SUM FLOWS AND FLOW WEIGHTED REAERATION COEFFICIENTS
ARE ANY MORE CHANNELS CONNECTED TO NODE J
YES
NO
CALCULATE FLOW WEIGHTED AVERAGE REAERATION COEFFICIENT
RETURN

FIGURE C-14. FLOW CHART FOR REAERATION SUBROUTINE REA

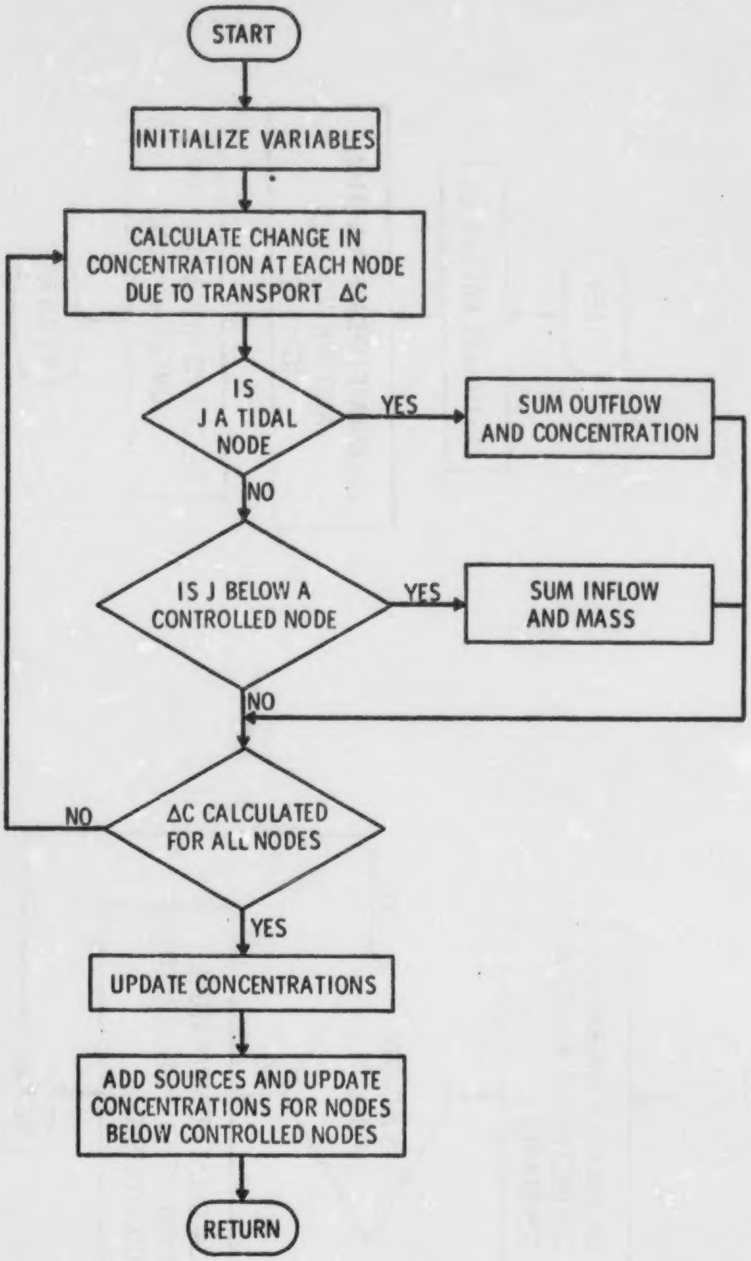
START
INITIALIZE VARIABLES
CALCULATE CHANGE IN CONCENTRATION AT EACH NODE DUE TO TRANSPORT ΔC
IS J A TIDAL NODE
YES
SUM OUTFLOW AND CONCENTRATION
NO
IS J BELOW A CONTROLLED NODE
YES
SUM INFLOW AND MASS
NO
ΔC CALCULATED FOR ALL NODES
NO
YES
UPDATE CONCENTRATIONS
ADD SOURCES AND UPDATE CONCENTRATIONS FOR NODES BELOW CONTROLLED NODES
RETURN

FIGURE C-15. FLOW CHART FOR TRANSPORT CALCULATION SUBROUTINE TRANSP

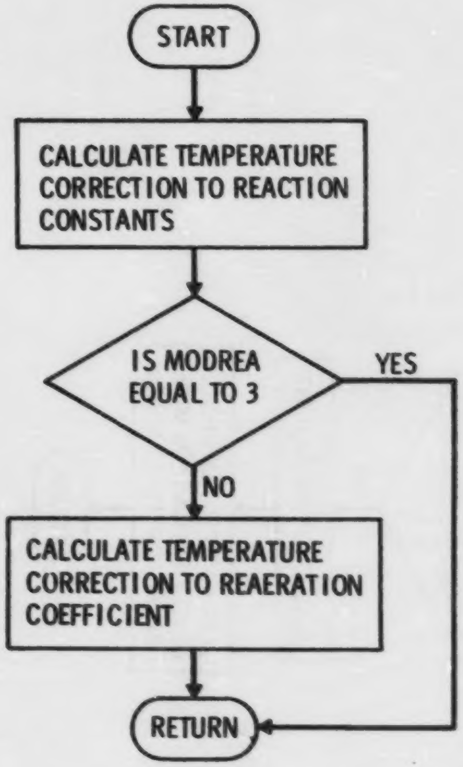
START
CALCULATE TEMPERATURE CORRECTION TO REACTION CONSTANTS
IS MODREA EQUAL TO 3
YES
NO
CALCULATE TEMPERATURE CORRECTION TO REAERATION COEFFICIENT
RETURN

FIGURE C-16. FLOW CHART FOR TEMPERATURE CORRECTION SUBROUTINE TEMPER

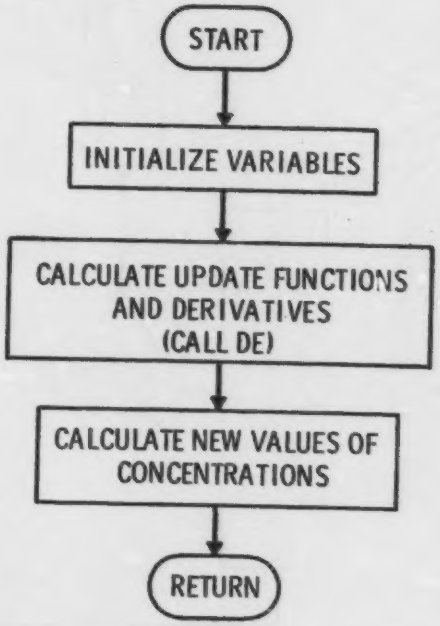
START
INITIALIZE VARIABLES
CALCULATE UPDATE FUNCTIONS AND DERIVATIVES (CALL DE)
CALCULATE NEW VALUES OF CONCENTRATIONS
RETURN

FIGURE C-17. FLOW DIFFERENTIAL EQUATION SOLUTION SUBROUTINE DIFEQ

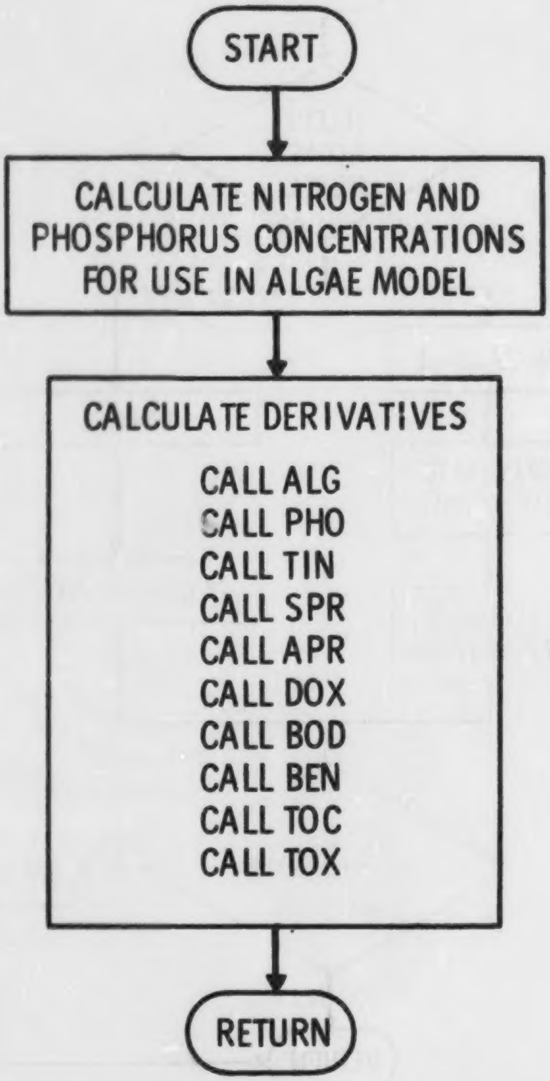
START
CALCULATE NITROGEN AND PHOSPHORUS CONCENTRATIONS FOR USE IN ALGAE MODEL
CALCULATE DERIVATIVES
CALL ALG
CALL PHO
CALL TIN
CALL SPR
CALL APR
CALL DOX
CALL BOD
CALL BEN
CALL TOC
CALL TOX
RETURN

FIGURE C-18. FLOW CHART OF DERIVATIVE CALCULATION SUBROUTINE DE

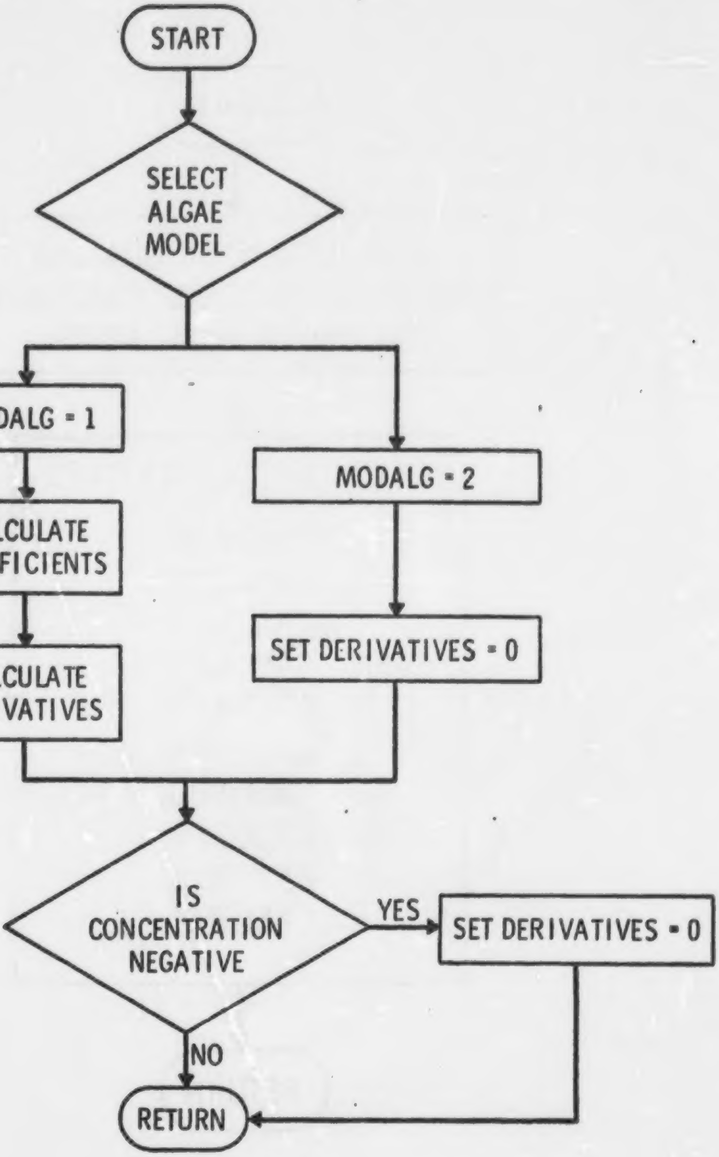
START
SELECT ALGAE MODEL
MODALG = 1
MODALG = 2
CALCULATE COEFFICIENTS
CALCULATE DERIVATIVES
SET DERIVATIVES = 0
IS CONCENTRATION NEGATIVE
YES
SET DERIVATIVES = 0
NO
RETURN

FIGURE C-19. FLOW CHART FOR ALGAE DERIVATIVE CALCULATION SUBROUTINE ALG

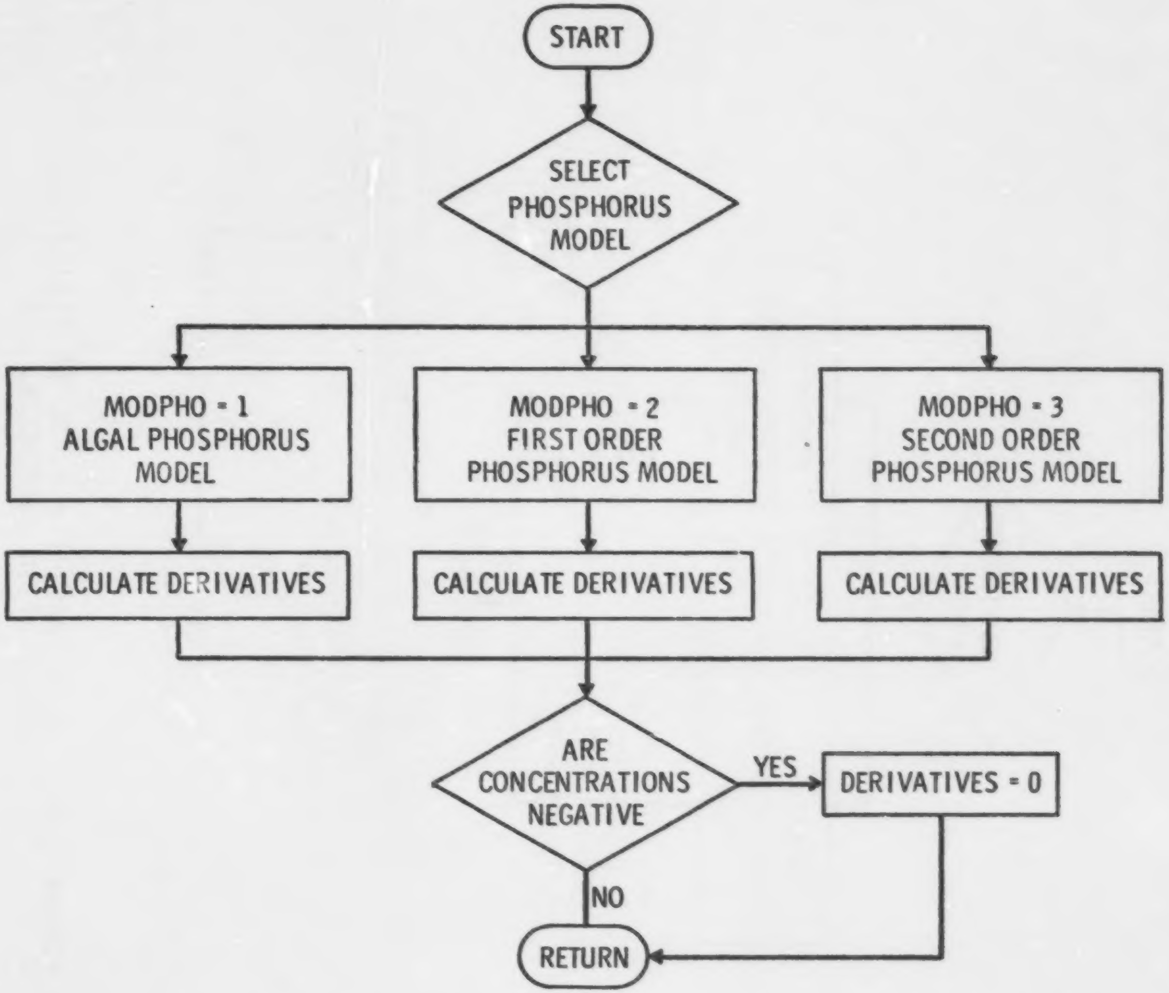
START
SELECT PHOSPHORUS MODEL
MODPHO = 1 ALGAL PHOSPHORUS MODEL
MODPHO = 2 FIRST ORDER PHOSPHORUS MODEL
MODPHO = 3 SECOND ORDER PHOSPHORUS MODEL
CALCULATE DERIVATIVES
CALCULATE DERIVATIVES
CALCULATE DERIVATIVES
ARE CONCENTRATIONS NEGATIVE
YES
DERIVATIVES = 0
NO
RETURN

FIGURE C-20. FLOW CHART FOR PHOSPHORUS DERIVATIVE CALCULATION SUBROUTINE PHO

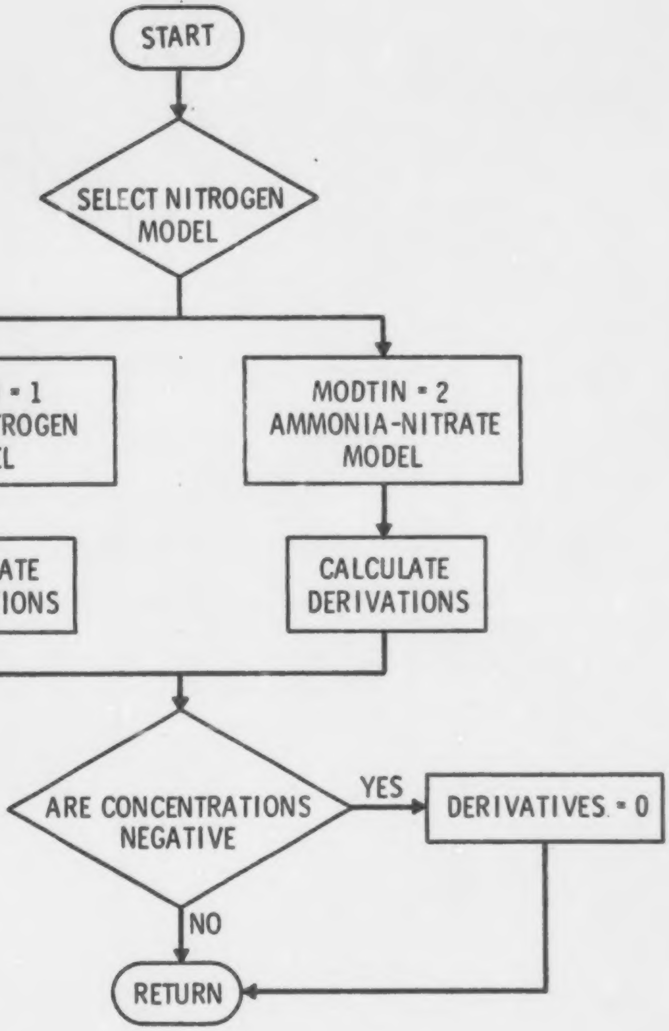
START
SELECT NITROGEN MODEL
MODTIN = 1 ALGAL NITROGEN MODEL
MODTIN = 2 AMMONIA-NITRATE MODEL
CALCULATE DERIVATIONS
CALCULATE DERIVATIONS
ARE CONCENTRATIONS NEGATIVE
YES
DERIVATIVES = 0
NO
RETURN

FIGURE C-21. FLOW CHART FOR NITROGEN DERIVATIVE CALCULATION SUBROUTINE TIN

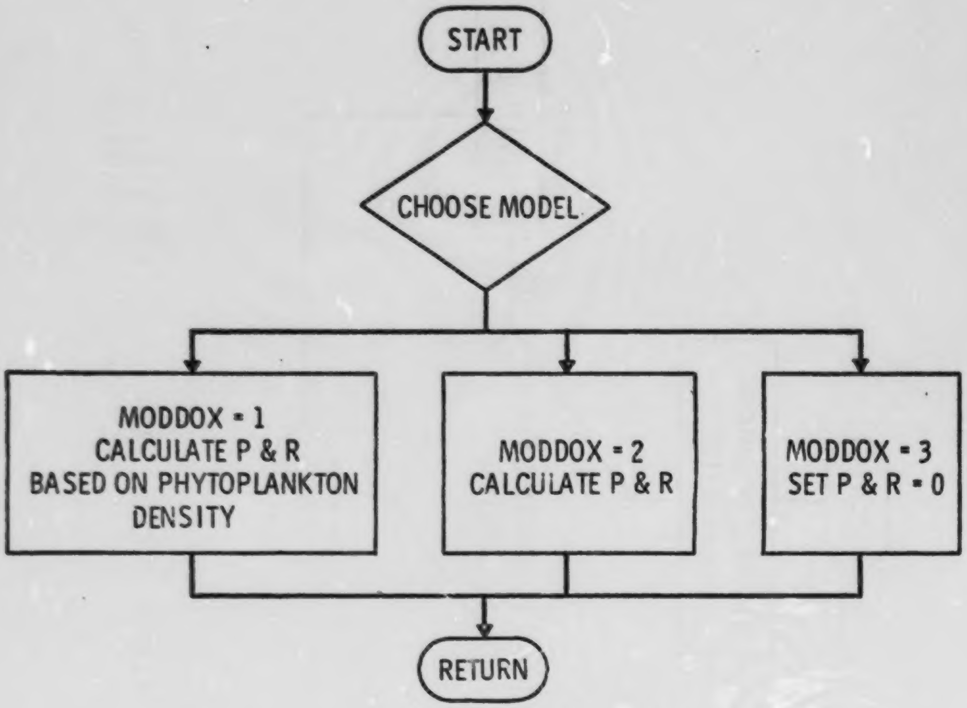
START
CHOOSE MODEL
MODDOX = 1
CALCULATE P & R
BASED ON PHYTOPLANKTON
DENSITY
MODDOX = 2
CALCULATE P & R
MODDOX = 3
SET P & R = 0
RETURN

FIGURE C-22. FLOW CHART OF SUSPENDED ALGAE OXYGEN PRODUCTION SUBROUTINE SPR

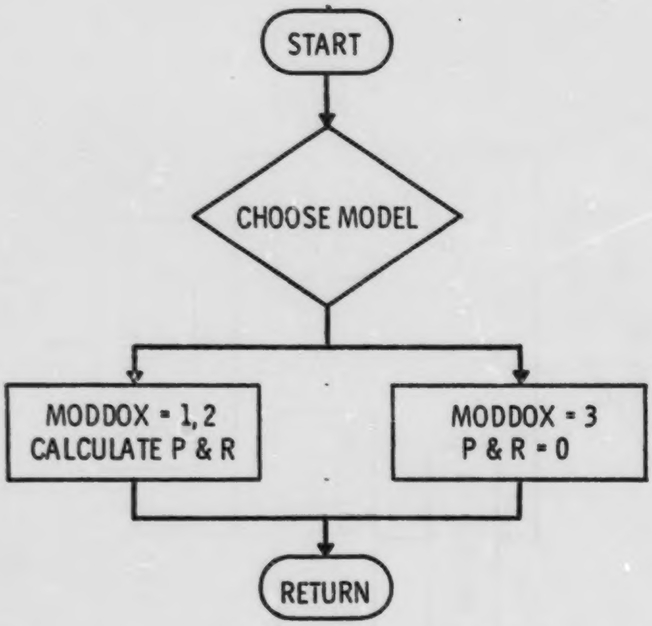
START
CHOOSE MODEL
MODDOX = 1,2
CALCULATE P & R
MODDOX = 3
P & R = 0
RETURN

FIGURE C-23. FLOW CHART FOR ATTACHED ALGAE PRODUCTION SUBROUTINE APR

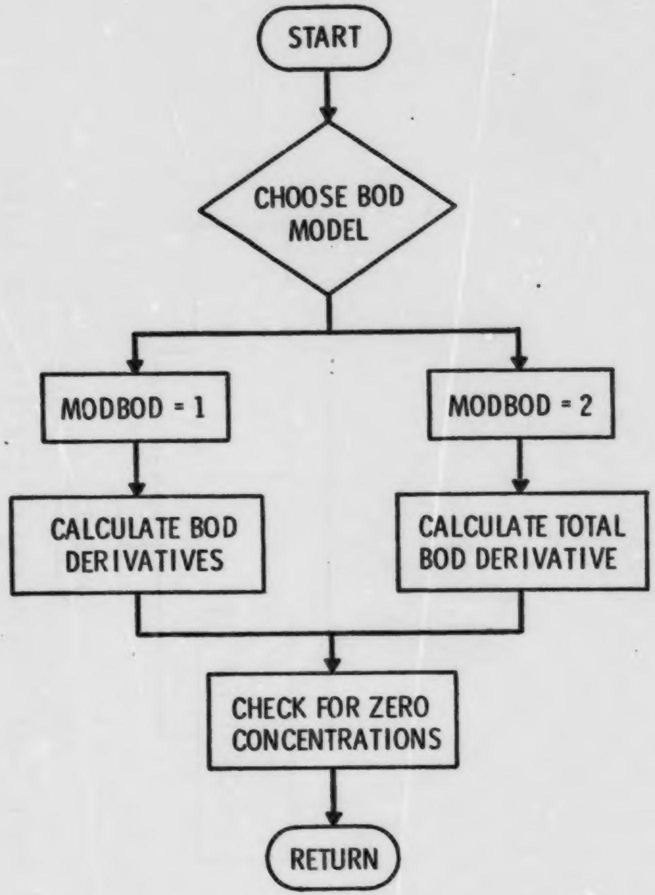
START
CHOOSE BOD MODEL
MODBOD = 1
MODBOD = 2
CALCULATE BOD DERIVATIVES
CALCULATE TOTAL BOD DERIVATIVE
CHECK FOR ZERO CONCENTRATIONS
RETURN

FIGURE C-24. FLOW CHART FOR BOD DERIVATIVE CALCULATION SUBROUTINE BOD

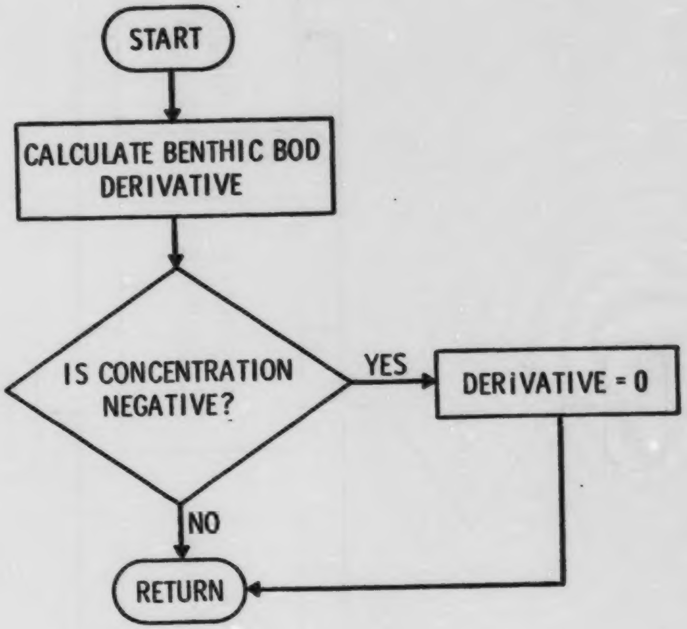
START
CALCULATE BENTHIC BOD DERIVATIVE
IS CONCENTRATION NEGATIVE?
YES
DERIVATIVE = 0
NO
RETURN

FIGURE C-25. FLOW CHART FOR BENTHIC BOD DERIVATIVE CALCULATION SUBROUTINE BEN

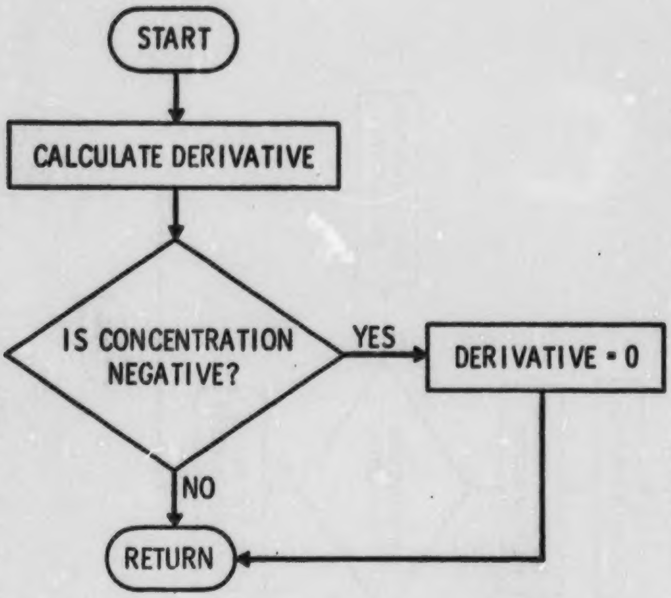
START
CALCULATE DERIVATIVE
IS CONCENTRATION NEGATIVE?
YES
DERIVATIVE = 0
NO
RETURN

FIGURE C-26. FLOW CHART FOR TOC DERIVATIVE CALCULATION SUBROUTINE TOC

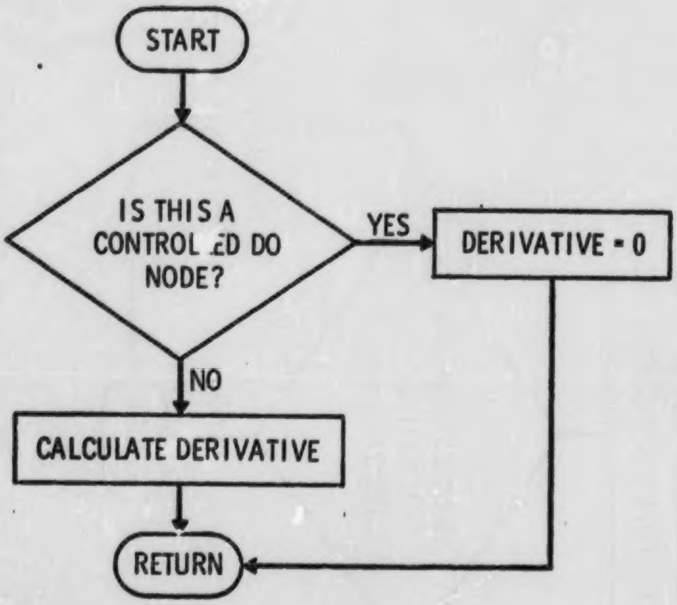
START
IS THIS A CONTROLLED DO NODE?
YES
DERIVATIVE = 0
NO
CALCULATE DERIVATIVE
RETURN

FIGURE C-27. FLOW CHART FOR DISSOLVED OXYGEN DERIVATIVE SUBROUTINE DOX

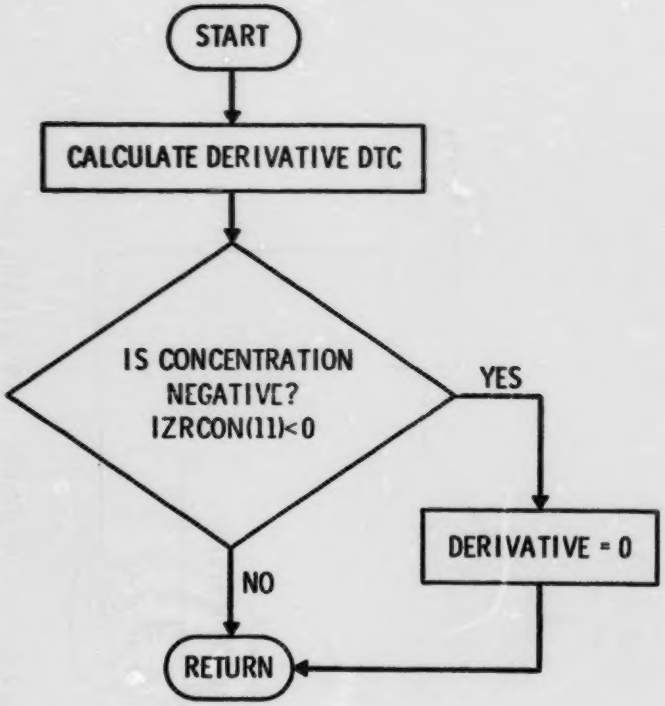
START
CALCULATE DERIVATIVE DTC
IS CONCENTRATION NEGATIVE? IZRCON(11)<0
YES
DERIVATIVE = 0
NO
RETURN

FIGURE C-28. FLOW CHART FOR TOXIC COMPOUND SUBROUTINE TOX

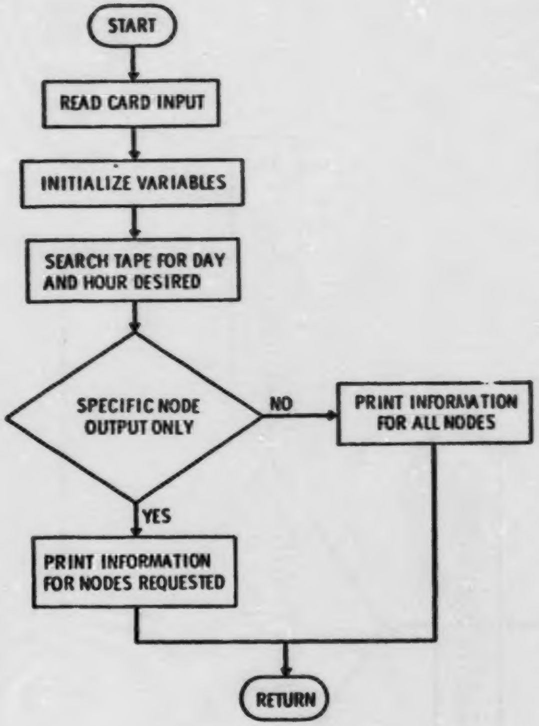
START
READ CARD INPUT
INITIALIZE VARIABLES
SEARCH TAPE FOR DAY AND HOUR DESIRED
SPECIFIC NODE OUTPUT ONLY
NO
PRINT INFORMATION FOR ALL NODES
YES
PRINT INFORMATION FOR NODES REQUESTED
RETURN

FIGURE C-29. FLOW CHART FOR LINE-PRINTER SUBROUTINE PRINT

The executable program REPRINT enables the user to obtain lineprinter output from previously created output data tape, thus supplying past calculation results without large amounts of original lineprinter output.

A list of the variables used in the quality codes is given in Table C-2. Figure C-30 is a listing of the input code and Figure C-31 is a listing of the calculational code.

TABLE C-2

VARIABLE DEFINITION FOR QUALITY CODE

Variable Name	Location	Description	Units
A(M,K,L)	C	Array for storing the regression coefficient of the time varying source functions	
ACON(L)	INQ	Array of concentration titles used in headers and print statements	
ADDC(L,K)	TRANSP	Temporary storage of mass below controlled nodes	$\frac{mg\ ft^3}{\ell\ sec}$
ADDCON(K)	TRANSP	Temporary storage of mass for source nodes	$\frac{mg\ ft^3}{\ell\ sec}$
ADDQ(K)	TRANSP	Temporary storage of flow below a controlled node	ft^3
ALEN(N)	ATRAN	Length of channel N	ft
ALGCAL(1)	AQUAL	Phytoplankton growth rate	mg/ℓ day
(2)	"	Phytoplankton death rate	mg/ℓ day
(3)	"	Zooplankton growth rate	mg/ℓ day
(4)	"	Zooplankton death rate	mg/ℓ day
(5)	"	Effective nitrogen concentration	mg/ℓ
(6)	"	Effective phosphorus concentration	mg/ℓ

Variable Name	Location	Description	Units
ALGIN(I,M)	AQUAL	Algae input constants	
ALPH(20)	C	Array used for listing input card deck	
ALPHA(M)	CLEAN,C	Hydraulic run title array	
ALPHAQ(M)	CLEAN,C	Quality input title array	
AM1(K)	DIFEQ	Calculated derivative Runge-Kutta solution	mg/ℓ day
AM2(K)	"	"	"
AM3(K)	"	"	"
AM4(K)	"	"	"
APRCAL(1)	AQUAL	Attached algae net DO production rate	mg/ℓ day
APRIN(I,M)	AQUAL	Attached algae input constants	
ARGU	REA	Temporary variable	
ARRAY(M)	C	Array used for reading fake printer file and transferring it to line-printer	
AS(J)	C	Junction surface area arrays	ft^2
ASTERK	INQ	Variable containing 4H****	
ATEMP(L)	C	Array for transferring regression coefficients	
B	REA	Temporary variable	
BENCAL(1)	AQUAL	Benthic deoxygenation constant corrected for temperature	1/day
BENIN(I,M)	AQUAL	Benthic input constants	
BODCAL(1)	AQUAL	Carbonaceous BOD deoxygenation constant corrected for temperature	1/day
(2)	"	Nitrogenous BOD deoxygenation constant corrected for temperature	1/day

Variable Name	Location	Description	Units
BODIN(I,M)	AQUAL	BOD input constants	
C(J,1)	BTRAN	Concentration at node J of benthic BOD	gm/m^2
C(J,2)		Concentration at node J of sedimentary phosphorus	mg/ℓ
,3		" soluble phosphorus	"
,4		" organic phosphorus	"
,5		" carbonaceous BOD	"
,6		" nitrogenous BOD	"
,7		" refractory organic carbon	"
,8		" total organic carbon	"
,9		" ammonia nitrogen	"
,10		" nitrite nitrogen	"
C(J,11)	BTRAN	Concentration at node J of nitrate nitrogen	mg/ℓ
,12		" organic nitrogen	"
,13		" toxic compound	"
,14		" phytoplankton	"
,15		" zooplankton	"
,16		" dissolved oxygen	"
COEF1	REA,ALG	Temporary variable	
2	REA,ALG	"	
3	REA,ALG	"	
4	REA	"	
5	REA	"	

Variable Name	Location	Description	Units
CONC(K)	C	Temporary array for storing the input values of concentration	
CONCIC(J,K)	C	Array for storing the initial conditions of concentration for each node	
CR	TOC	Refractory organic carbon concentration	mg/ℓ
CT	TOC	Total organic carbon concentration	"
CTEMP	TIN	Temporary variable	
C1	TIN	Ammonia nitrogen concentration	"
C2	TIN	Nitrite nitrogen concentration	"
C3	TIN	Nitrate nitrogen concentration	"
C4	TIN	Organic nitrogen concentration	"
DAYS	CLEAN	Counter for number of days	
DCDT(J,K)	TRANSP	Stores change in concentration due to convection	mg/ℓ day
DCRDT	TOC	Change in refractory organic carbon due to reactions	"
DCTDT	TOC	Change in total organic carbon due to reactions	"
DC1DT	TIN	Change in ammonia nitrogen due to reactions	mg/ℓ day
DC2DT	"	" nitrite nitrogen "	"
DC3DT	"	" nitrate nitrogen "	"
DC4DT	"	" organic nitrogen "	"
DDODT	DOX	" dissolved oxygen "	mg/ℓ day
DD1DT	PHO	" sedimentary phosphorus	"
DD2DT	PHO	" soluble phosphorus	"
DD3DT	PHO	" organic phosphorus	"

Variable Name	Location	Description	Units
D1	PHO	Concentration of sedimentary phosphorus	mg/ℓ
D2	PHO	" soluble phosphorus	"
D3	PHO	" organic phosphorus	"
DELTD	CLEAN	Time step in days	days
DELTH	CLEAN	Time step in hours	hours
DELTQ	C	Quality time step	seconds
DELTS	ATRAN	Time step in seconds	seconds
DEP(J)	BTRAN C	Elevation of river bottom at node J	ft
DEPTH	BQUAL	Temporary storage for depth	
DEPT1	REA	Temporary variable	
DEPT2	REA	Temporary variable	
DLCDT	BOD	Change in carbonaceous BOD due to reactions	mg/ℓ day
DLDDT	BEN	" benthic BOD	"
DLNDT	BOD	" nitrogenous BOD	"
DO	DOX	Concentration of dissolved oxygen	mg/ℓ
DOCONT(L)	BTRAN	Pointer array for specification of DO concentration below controlled nodes	
DOXCAL(1)	AQUAL	Saturated DO concentration	mg/ℓ
DOXCAL(2)	AQUAL	DO production when total DO is zero	mg/ℓ
DPDT	ALG	Change in phytoplankton due to reactions	mg/ℓ day
DS(M,L)	C	Storage for the regression coefficients for the time varying controlled channel dissolved oxygen concentration function	

Variable Name	Location	Description	Units
DSOUR(M)	C	Array of dissolved oxygen concentrations for the NJGW controlled channels	
DTCDT	TOX	Change in phytoplankton due to toxic compounds	mg/ℓ day
DTEMP	ALG	Temporary variable	
DZDT	ALG	Change in zooplankton due to reactions	mg/ℓ day
EVAP	ATRAN C	Evaporation rate	inches/month
F(K,1)	DE	Derivative of Kth concentration	
FI	DIFEQ	Temporary variable	
FLOW	TRANSP	Temporary storage variable for flow below controlled nodes	ft^3/sec
FLOW	REA	Temporary storage variable for flow in a channel	ft^3/sec
H	DIFEQ	Integration interval	days
HBAR(J)	BTRAN	Elevation of water surface level at node J	ft
HOURS	ALL	Time of day	hours
H1	CLEAN C	Number of intervals the time step will be divided into for integration	
I	ALL	Reach number	
I	DIFEQ	Integration divisions	
I	INQ	Temporary variable	
IAK	C	Temporary variable and flag	
IC	INQ	Switch for selecting the input format for concentrations	
ICN	C	DO loop index for concentrations	
ICNTND(M)	BTRAN	Pointer array to identify type of controlled node	

Variable Name	Location	Description	Units
ICONST	CLEAN	Option variable for all constant input	
ICYCLE	CLEAN	Counter for number of time steps taken	
IDOCNT	ALL	Flag for node below controlled node where DO is specified	
IDONE	INQ	Done flag	
IH	INQ	Temporary variable used in paging	
IHOUR	CLEAN	Hour for restart	
IHR	CLEAN	Temporary variable	
IKC	INQ	Header selection index	
IL	INQ	Index variable	
INEB	C	Neighbor index	
INTER	CLEAN	Integration interval	
IPOINT(J,L)	C	Array of junction numbers which are neighbors of junction J	
IRBND(K)	C	Array used to define the end points of a reach	
IREA	C	Reach number DO index	
IREACH(J)	BTRAN	Pointer array to identify reach number of node J	
IREADC	CLEAN	Counter for reading hydraulic tape	
IRECH(M)	C	Temporary array of reach numbers used in inputting parameter values	
IREWND	CLEAN	Counter for rewinding hydraulic tape	
ISOP(M)	C	Array of the NSOURC junction numbers where sources are to be dumped	
ISOURC(L)	BTRAN	Pointer array for source nodes	
IST	INQ	Number of constant upstream nodes plus one	
ISTART	CLEAN	Restart option	

Variable Name	Location	Description	Units
IT	TRANSP	Temporary variable	
ITCYC	CLEAN	Restart cycle number	
ITEMP	CLEAN	Temporary variable	
ITID	CLEAN	Temporary variable	
ITIDE	ATRAN	Initializing variable for tidal cycle	
ITIMS	C	Iteration counter	
IT1	REA	Temporary variable	
IT2	REA	Temporary variable	
IT3	REA	Temporary variable	
IUP(M)	C	Temporary array of upstream node numbers (unordered)	
IUPSTR(L)	BTRAN	Ordered pointer array for upstream nodes	
IZER	C	Flag variable used in marking nodes which belong in a reach	
IZRCHK	CLEAN	Flag for negative concentration	
IZRCON(K)	BQUAL	Flag for negative concentration of Kth parameter	
J	BQUAL	Node number	
J	DIFEQ INQ	Temporary variable	
JGW(M)	INQ	Array containing the codes specifying the type of controlled nodes	
JH	TRANSP	Upstream node	
JL	TRANSP	Downstream node	
JT	CLEAN	Temporary variable	
K	CLEAN DIFEQ TRANSP INQ	Temporary variable	

Variable Name	Location	Description	Units
KALE	INQ	Print paging variable	
KC	CLEAN TRANSP	Temporary variable	
KCON	CLEAN	Number of concentrations	
KIL	INQ	Index variable	
KK	"	Index variable	
KKL	"	Index variable	
KL	"	Print paging variable and DO index variable	
KT	CLEAN	Temporary variable	
KUPSTR	CLEAN	Flag for upstream node	
K1	INQ	Index variable	
K2	INQ	K1 + 1	
L	CLEAN INQ	Temporary variable	
LAST	INQ	Number of upstream nodes minus one	
LEN(N)	INQ	Array of channel lengths	ft
LST	INQ	Number of constant upstream nodes plus the number of time varying upstream nodes	
M	INQ	DO index variable	
MAXCON	CLEAN	Number of concentrations	
MAXNWE	CLEAN	Maximum number of channels connected to a node	
MAXREA	C	Maximum number of reaches	
MAXSOR	C	Maximum number of sources	
MODALG	BQUAL,C	Option for algae model	
MODBOD	"	Option for BOD model	

Variable Name	Location	Description	Units
MODDOX	"	Option for DO model	
MODPHO	"	Option for phosphorus model	
MODREA	BQUAL,C	Option for reaeration model	
MODTIN	"	Option for nitrogen model	
N	CLEAN	Temporary variable	
N	TRANSP	Temporary variable	
NC	CLEAN	Number of channels in system	
NCHAN(J,M)	BTRAN	Pointer array for number of channels connected to node J	
NCNTND	ATRAN	Number of controlled nodes	
NCSOUR	C	Number of quality source points	
NCUPS	INQ	Number of constant upstream nodes	
NCYCLE	CLEAN	Total number of time steps code will run	
NHDAY	CLEAN	Temporary variable	
NJ	ALL,C	Number of junctions in system	
NJGW	C	Number of controlled nodes	
NJUNC(N,M)	BTRAN	Pointer array for number of junctions at each end of channel N	
NLAS	INQ	Last tidal day for which time varying quality data is generated	
NN	DIFEQ	Temporary variable	
NQ	CLEAN INQ	Quality cycle number from quality input tape	
NQCYC	CLEAN	Number of quality cycles per tidal cycle	
NQSWRT	CLEAN	Number of first tidal cycles for which hydraulic data is written	

Variable Name	Location	Description	Units
NQ1	CLEAN	Quality cycle number from hydraulic tape	
NREACH	ATRAN	Number of reaches in system	
NREADC	CLEAN	Number of quality cycles written on hydraulic tape	
NS	INQ	DO index variable	
NSOURC	ATRAN	Number of source nodes	
NS1	INQ	The number of constant sources plus one	
NT	INQ	Tidal day number index	
NT	CLEAN	Tidal day number read off of quality tape	
NTA	CLEAN	Unit quality tape is mounted on	
NTB	CLEAN	Unit hydraulic tape is mounted on	
NTC	CLEAN	Unit output tape is mounted on	
NTCYC	CLEAN,C	Number of last tidal cycle simulated by hydraulic code	
NTQCYC	CLEAN	Number of last quality cycles to be simulated by the quality code	
NTVUPS	INQ	Number of time varying upstream nodes	
NT1	CLEAN	Tidal cycle number read off of hydraulic tape	
NUPSTR	ATRAN	Number of upstream nodes	
NUS	INQ	Maximum number of upstream nodes	
N20	C	Hydraulic input file	
N22	C	Quality output file	
N24	C	Scratch file for storing card images	
N5	C	Card reader	

Variable Name	Location	Description	Units
N6	C	Lineprinter	
N7	C	Scratch file (fake printer)	
OUTFLO	TRANSP	Stores flow out during ebb tide	ft^3
P	SPR,PHO TIN,ALG	Phytoplankton concentration	mg/ℓ
PARAM(L,M)	C	Array used to store the coefficients for each reach	
PARM(17)	C	Dummy array used to input coefficients	
PERIOD	CLEAN	Number of hours in a tidal cycle	
PHOIN(I,M)	AQUAL	Phosphorus input constants	
Q(N)	BTRAN	Flow in channel N	ft^3/sec
QINBAR(J)	BTRAN	Flow added at node J	ft^3/sec
QOUBAR(J)	BTRAN	Flow removed from node J	ft^3/sec
QTEMP	REA	Temporary variable	
REACAL(1)	AQUAL	Reaeration coefficient before temperature correction	1/day
REACAL(2)	AQUAL	Reaeration coefficient after temperature correction	1/day
REAIN(I,M)	AQUAL	Reaeration input constants	
REATEM(M,J)	CLEAN	Temporary variable	
RETEM1	REA	Temporary variable for calculating reaeration coefficient in each channel	
RETEM2	REA	Temporary variable for summing reaeration coefficient	
RLC	DOX,BOD TOC,BEN	Carbonaceous BOD concentration	mg/ℓ
RLD	DOX,BEN	Benthic BOD concentration	mg/ℓ
RLN	DOX,BOD	Nitrogenous BOD concentration	mg/ℓ

Variable Name	Location	Description	Units
SLOPE	REA	Slope of the channel	ft/ft
SOURIN(J,K)	AQUAL	Source values of Kth concentration at node J	lbs/day
SPRCAL(1)	AQUAL	Net DO contribution of suspended algae	mg/ℓ day
SPRIN(I,M)	AQUAL	Suspended algae input constants	
SUMQ	TRANSP	Sums flows in junction	ft^3/sec
SURFAR(J)	BTRAN	Surface area of junction J	$10^6 ft^2$
TC	TOX	Toxic compound concentration	mg/ℓ
TEMP(M,L)	C	Array of regression coefficients generated to fit the temperature versus time functions for each reach	
TEMP(I)	CLEAN	Temperature of reach I	°C
TEMPR	BQUAL	Temperature	
TEMPR1	TEMPER	Temporary variable	
TEMPS(M)	C	Array of temperature values for each reach at time = TIME	
TIDCOF	ATRAN	Tidal exchange coefficient	
TIDEXC	C	Tidal exchange coefficient	
TIDMAS(K)	TRANSP	Sums parameter mass leaving system during ebb tide	$mg\ ft^3/\ell$
TIME	C	Time variable used to generate the time varying concentration functions	hours
TININ(I,M)	AQUAL	Nitrogen input constants	
TOCCAL(1)	AQUAL	Total organic carbon removal constant corrected for temperature	1/day
TOCIN(I,M)	AQUAL	Total organic carbon input constants	
TOXCAL(1)	AQUAL	Toxic compound rate constant corrected for temperature	1/day

Variable Name	Location	Description	Units
TOXIN(I,M)	AQUAL	Toxic compound input constants	
U(N)	BTRAN	Velocity in channel N	ft/sec
UPSTR(M,K,L)	C	Array for storing the regression coefficients for the time varying upstream node concentration functions	
UPSTR(L,K)	BTRAN	Values of Kth concentration at Lth upstream node	mg/ℓ
VARB(M,K)	C	Array for storage of the values of the quality source values at time = TIME	
VELO	REA	Velocity	ft/sec
VOL(J)	BTRAN	Volume of node J	ft^3
XE	DIFEQ	Initial integration point	
XF	DIFEQ	Final integration point	
Y(K)	CLEAN DIFEQ	Concentration of Kth parameter	mg/ℓ
YF(K)	DIFEQ	Concentration of Kth parameter	mg/ℓ
YI(K)	DIFEQ	Concentration of Kth parameter	mg/ℓ
YO(K)	CLEAN	Concentration of Kth parameter	mg/ℓ
ZERRERR	TRANSP	Temporary variable	
Z	PHO,TIN ALG	Phytoplankton concentration	mg/ℓ

FIGURE C-30. LISTING OF THE QUALITY INPUT COMPUTER PROGRAM FOR EXPLORE-I

```
C     *************** MAIN PROGRAM FOR EXPLORE-1 INPUT     *************
C     *************** BATTELLE NORTHWEST 11/9/71           *************
C     *****************************************************************
C
C     QMAINT A PROGRAM TO PREPARE THE INPUT FOR THE WATER QUALITY
C     CODE CLEAN.
C     PROGRAMMED BY C. R. COLE
C                   BATTELLE NORTHWEST
C                   P O BOX 999
C                   RICHLAND, WASHINGTON
C      THIS PROGRAM IS PART OF THE BNW EXPLORE-I PROGRAM FOR
C      CALCULATION OF WATER QUALITY IN A RIVER BASIN
C
C     ************** ASSIGN THE COMMON  DATA               *************
      COMMON /TAPES/N5,N6,N20,N22,N24,N7
      COMMON/PARAMS/I21,I22,I25,I26,I29,I212,I213,MAXUPS
C
C     ************** CONTROL AND TITLE INFORMATION         *************
      COMMON /PTINT/ NJ,NC,NJGW,NTCYC,NQSWRT,NQCYC,DELTQ,PERIOD,
     1ALPHA(30),DEP(500),IPOINT(500,6),AS(500),EVAP
      COMMON/QUAL/NCHAN(500,6),LEN(600),NJUNC(600,2),JGW(20)
C
      REAL LEN
C     *************  ASSIGN THE UNIT NUMBERS AND REWIND    *************
```

```
C
      IZ1=50
      IZ2=50
      IZ5=500
      IZ6=6
      IZ9=600
      IZ12=20
      IZ13=20
      MAXUPS=50
      N7=1
      N5=5
      N6=6
      N20=2
      N22=3
      N24=4
      REWIND N20
      REWIND N22
      REWIND N24
      REWIND N7
C     **************          END                   *************
      READ (N20) (ALPHA(I), I=1, 30), NJ, NC, NQCYC, DELTQ, NTCYC, NQSWRT, NJGW, E
     1VAP, ((NCHAN(J, K), K=1, IZ6), DEP(J), AS(J), J=1, NJ), (LEN(N), (NJUNC(N, K)
     2, K=1, 2), N=1, NC), PERIOD, (JGW(I), I=1, NJGW)
      READ (N20) ((IPOINT(J, K), K=1, IZ6), J=1, NJ)
      CALL INQ
      REWIND N20
      REWIND N22
      REWIND N24
C     **************          END                   *************
      STOP
      END
      SUBROUTINE IN0
C     ************** BATTELLE NORTHWEST 11/9/71          *************
C     *****************************************************************
C
C
C     ************** ASSIGN THE COMMON  DATA              *************
      COMMON /TAPES/N5,N6,N20,N22,N24,N7
      COMMON/PARAMS/IZ1,IZ2,IZ5,IZ6,IZ9,IZ12,IZ13,MAXUPS
C
C     ************** CONTROL AND TITLE INFORMATION       *************
      COMMON /PTINT/ NJ,NC,NJGW,NTCYC,NOSHRT,NOCYC,DELTQ,PERIOD,
     1ALPHA(30),DEP(500),IPOINT(500,6),AS(500),EVAP
      COMMON/QUAL/NCHAN(500,6),LEN(600),NJUNC(600,2),JGW(20)
C
C     ************** ASSIGN THE BLANK COMMON DATA        *************
      COMMON IWELL,ARRAY(33),ALPHAQ(20),ALPH(20)
      COMMON IREA,IAK,INFR,ITIMS,IZER,NREACH,MAXREA,IREACH(500),IREND(16
     1),IRECH(50),PARAM(17,50),PARM(17),TEMP(50,5),TEMPS(50)
      COMMON ISTART,MODEL,MODREA,MODPHO,MODTIN,H1
      COMMON NSOURC,MAXSOR,ISUP(50),VHR3(50,16),A(50,16,5),NCONC,ICN
     1,NCN,TIME
      COMMON ATEMP(10)
      COMMON DSOUR(20),DS(20,5)
      COMMON CONCIC(500,16),CONC(16),IUPSTR(50),NUPSTR,TIDEXC,
     1UPSTR(50,16,6),IUP(50)
C
      REAL LEN
C
      DIMENSION ACON(32)
      DATA (ACON(I),I=1,32)/
     1  6H BEN B ,6HOD     ,6H SED P ,6HHOS    ,6H SOL P ,6HHOS
     2, 6H ORG P ,6HHOS    ,6H CAR B ,6HOD     ,6H NIT B ,6HOD
     3, 6H REF 0 ,6HC      ,6H TOC   ,6H       ,6H NH3   ,6H          ,
     4  6H NO2   ,6H       ,6H NO3   ,6H       ,6H ORG N ,6H
     5, 6H TOXIC ,6H       ,6H PHYTO ,6H       ,6H ZOO   ,6H          ,
     6  6H DO    ,6H       /
      DATA ASTERK/4H****/
C     **************                   END                *************
C
C
C     ************** MAKE  A LISTING OF THE INPUT DATA DECK ************
C
100   CONTINUE
      READ (N5,1190) (ALPH(I),I=1,20)
      WRITE (N6,1200) (ALPH(I),I=1,20)
      IF (ALPH(1).EQ.ASTERK) GO TO 110
      WRITE (N24,1190) (ALPH(I),I=1,20)
      GO TO 100
110   CONTINUE
      WRITE (N6,1210)
      END FILE N24
      REWIND N24
      N5=N24
C     **************             END                  *************
C
C     ************** INITIALIZE  THE NECESSARY ARRAYS  *************
      DO 120 I=1,I25
120   IREACH(I)=0
C     **************             END                  *************
C
C
C     ************** READ IN CARD GROUP 01             *************
      READ (N5,1220) (ALPHAO(I),I=1,20)
C     **************             END                  *************
C
C     ************** READ IN CARD GROUP 02             *************
      READ (N5,1230) ISTART,MODBOD,MODDOX,MODREA,MODPHO,MODTIN,MODALG,TI
     1DEXC,H1,NTQCYC,NUPSTR,NREACH,NSOURC,ICONST
      IF ((MODALG.LT.1).OR.(MODALG.GT.2)) MODALG=2
      IF ((MODBOD.LT.1).OR.(MODBOD.GT.2)) MODBOD=2
      IF ((MODDOX.LT.1).OR.(MODDOX.GT.3)) MODDOX=3
      IF ((MODTIN.LT.1).OR.(MODTIN.GT.2)) MODTIN=2
      IF ((MODPHO.LT.1).OR.(MODPHO.GT.3)) MODPHO=3
      IF ((MODREA.LT.1).OR.(MODREA.GT.4)) MODREA=4
      IF ((ISTART.LT.0).OR.(ISTART.GT.1)) ISTART=0
      IF ((ICONST.LT.0).OR.(ICONST.GT.1)) ICONST=0
      IF (NREACH.LE.IZ1) GO TO 130
      MAXREA=IZ1
      WRITE (N6,1240) NREACH,MAXREA
      STOP
130   IF (NSOURC.LE.IZ2) GO TO 140
      MAXSOR=IZ2
      WRITE (N6,1250) NSOURC,MAXSOR
      STOP
140   IF (NUPSTR.LE.MAXUPS) GO TO 150
      NUS=MAXUPS
      WRITE (N6,1260) NUPSTR,NUS
      STOP
C     **************             END                  *************
C
C     ************** READ IN CARD GROUP 03             *************
150   IF (NUPSTR.LE.0) GO TO 220
      READ (N5,1270) (IUPSTR(I),I=1,NUPSTR)
      DO 160 I=1,NUPSTR
160   IUP(I)=IUPSTR(I)
      IF (NUPSTR.GT.1) GO TO 170
      IUPSTR(1)=1
      GO TO 220
170   CONTINUE
      L=0
      LAST=NUPSTR-1
      DO 180 K1=1,LAST
      K2=K1+1
      IF (IUP(K2).GE.IUP(K1)) GO TO 180
      L=1
      K=IUP(K1)
      IUP(K1)=IUP(K2)
      IUP(K2)=K
180   CONTINUE
      IF (L.GT.0) GO TO 170
      DO 210 K=1,NUPSTR
      I=IUPSTR(K)
      DO 190 J=1,NUPSTR
      IF (I.EQ.IUP(J)) GO TO 200
190   CONTINUE
      GO TO 210
200   IUPSTR(K)=J
210   CONTINUE
220   CONTINUE
C     **************               END                        *************
C
C     ************* WRITE OUT PAGE 1 THE CONTROL DATA         *************
      WRITE (N7,1280) ALPHA,ALPHAQ
      IF (ISTART.EQ.0) GO TO 230
      WRITE (N7,1290)
230   WRITE (N7,1300)
      IF (ICONST.EQ.0) GO TO 235
      WRITE (N7,1285)
235   CONTINUE
      GO TO (240,250), MODALG
240   WRITE (N7,1310)
      GO TO 260
250   WRITE (N7,1320)
260   GO TO (270,280), MODBOD
270   WRITF (N7,1330)
      GO TO 290
280   WRITE (N7,1340)
290   GO TO (300,310,320), MODDOX
300   WRITE (N7,1350)
      GO TO 330
310   WRITF (N7,1360)
      GO TO 330
320   WRITE (N7,1370)
330   GO TO (340,350), MODTIN
340   WRITE (N7,1380)
      GO TO 360
350   WRITE (N7,1390)
360   GO TO (370,380,390), MODPHO
370   WRITE (N7,1400)
      GO TO 400
380   WRITE (N7,1410)
      GO TO 400
390   WRITE (N7,1420)
400   GO TO (410,420,430,440), MODREA
410   WRITE (N7,1430)
```

```
       GO TO 450
 420   WRITE (N7,1440)
       GO TO 450
 430   WRITE (N7,1450)
       GO TO 450
 440   WRITE (N7,1460)
 450   IF (TIDEXC.LE.0) GO TO 460
       WRITE (N7,1470) TIDEXC
 460   CONTINUE
       WRITE (N7,1480) H1,NTQCYC,NJ,NC
       IF (NUPSTR.LE.0) GO TO 470
       WRITE (N7,1490) NUPSTR,(IUP(I),I=1,NUPSTR)
 470   CONTINUE
       WRITE (N7,1500) NREACH
C      *************               END                           *************
C
C      ************* READ IN CARD GROUP 04                       *************
       IF (NREACH.GT.0) GO TO 480
       WRITE (6,1510) NREACH
       STOP
 480   CONTINUE
       DO 510 IREA=1,NREACH
       READ (N5,1520) (IRBND(I),I=1,16)
       IAK=1
C      ************* MARK THE BOUNDARIES IN THE REACH ARRAY*************
       DO 490 I=1,16
       J=IRBND(I)
       IF (J.LE.0) GO TO 500
       IAK=I
 490   IREACH(J)=-IREA
 500   WRITE (N7,1530) IREA,(IRBND(I),I=1,IAK)
 510   CONTINUE
C      *************               END                           *************
C
C      ************* MARK ALL THE NODES ACCORDING  TO REACH*************
       ITIMS=0
 520   IZER=0
       DO 550 I=1,NJ
       IREA=IREACH(I)
       IF (IREA.EQ.0) GO TO 540
       IF (IREA.GT.0) GO TO 550
       IREACH(I)=-IREA
       DO 530 J=1,IZ6
       INEB=IPOINT(I,J)
       IF (INEB.LE.0) GO TO 530
       IF (IREACH(INEB).EQ.0) IREACH(INEB)=IREA
       IZER=1
 530   CONTINUE
       GO TO 550
 540   IZER=1
 550   CONTINUE
       IF (IZER.EQ.0) GO TO 570
```

```
      IF (ITIMS.GE.NJ) GO TO 560
      GO TO 520
560   WRITE (N6,1540)
      WRITE (N6,1550) (I,IREACH(I),I=1,NJ)
      STOP
570   CONTINUE
C     **************              END                  *************
C
C     ************** OUTPUT PAGE 2 THE REACH INFORMATION   *************
      WRITE (N7,1280) ALPHA,ALPHAQ
      DO 600 IREA=1,NREACH
      J=0
      DO 590 I=1,NJ
      IF (IREACH(I).EQ.IREA) GO TO 580
      GO TO 590
580   J=J+1
      IPOINT(J,1)=I
590   CONTINUE
      IF (J.EQ.0) GO TO 600
      WRITE (N7,1560) IREA
      WRITE (N7,1570) (IPOINT(I,1),I=1,J)
600   CONTINUE
C     **************              END                  *************
C
C     ************** READ IN CARD GROUP Q5                 *************
      IF (NSOURC.LE.0) GO TO 610
      READ (N5,1580) (ISOP(I),I=1,NSOURC)
C     **************              END                  *************
C
C     ************** OUTPUT PAGE 3 SOURCE DATA             *************
      WRITE (N7,1280) ALPHA,ALPHAQ
      WRITE (N7,1590) NSOURC,NSOURC
      WRITE (N7,1600) (ISOP(I),I=1,NSOURC)
610   CONTINUE
      WRITE (N22) (ALPHAQ(I),I=1,20),ISTART,MODALG,MODBOD,MODDOX,MODTIN,
     1MODPHO,MODREA,NREACH,NSOURC,H1,(IREACH(I),I=1,NJ),(ISOP(I),I=1,NSO
     2URC),NUPSTR,TIDEXC,(IUP(I),I=1,NUPSTR),NTQCYC,ICONST
C     **************              END                  *************
C
C     **************    READ IN Q6 CARDS -- BOD CONSTANTS  *************
      I=0
      CALL ZERO (6,4,6)
620   CONTINUE
      IF (MOD(I,9).EQ.0) WRITE (N7,1280) ALPHA,ALPHAQ
      IF (MOD(I,9).EQ.0) WRITE (N7,1610)
      I=I+1
      CALL PARAME (6,IDONE,4,6)
      IF (IDONE.EQ.0) GO TO 620
      WRITE (N22) ((PARAM(K,J),J=1,6),K=1,NREACH)
C     **************              END                  *************
C
C     ************** READ IN Q7 CARDS -- BENTHIC CONSTANTS *************
```

```
      I=0
      CALL ZERO (2,2,0)
  630 CONTINUE
      IF (MOD(I,9).EQ.0) WRITE (N7,1280) ALPHA,ALPHAQ
      IF (MOD(I,9).EQ.0) WRITE (N7,1620)
      I=I+1
      CALL PARAME (2,IDONE,2,0)
      IF (IDONE.EQ.0) GO TO 630
      WRITE (N22) ((PARAM(K,J),J=1,2),K=1,NREACH)
C     **************                  END               *************
C
C     **************  READ IN Q8 CARDS -- TOC CONSTANTS     *************
      I=0
      CALL ZERO (6,6,0)
  640 CONTINUE
      IF (MOD(I,9).EQ.0) WRITE (N7,1280) ALPHA,ALPHAQ
      IF (MOD(I,9).EQ.0) WRITE (N7,1630)
      I=I+1
      CALL PARAME (6,IDONE,6,0)
      IF (IDONE.EQ.0) GO TO 640
      WRITE (N22) ((PARAM(K,J),J=1,6),K=1,NREACH)
C     **************                  END               *************
C
C     **************  READ IN Q9 CARDS -- TOXIC CONSTANTS  *************
      I=0
      CALL ZERO (3,3,0)
  650 CONTINUE
      IF (MOD(I,9).EQ.0) WRITE (N7,1280) ALPHA,ALPHAQ
      IF (MOD(I,9).EQ.0) WRITE (N7,1640)
      I=I+1
      CALL PARAME (3,IDONE,3,0)
      IF (IDONE.EQ.0) GO TO 650
      WRITE (N22) ((PARAM(K,J),J=1,3),K=1,NREACH)
C     **************                  END               *************
C
C     ************** READ IN Q10 CARDS SUSPENDED ALGAL    *************
      I=0
      CALL ZERO (5,0,0)
  660 CONTINUE
      IF (MOD(I,9).EQ.0) WRITE (N7,1280) ALPHA,ALPHAQ
      IF (MOD(I,9).EQ.0) WRITE (N7,1650)
      I=I+1
      CALL PARAME (5,IDONE,0,0)
      IF (IDONE.EQ.0) GO TO 660
      WRITE (N22) ((PARAM(K,J),J=1,5),K=1,NREACH)
C     **************                  END               *************
C
C     ************** READ IN Q11 CARDS ATTACHED ALGAL     *************
      I=0
      CALL ZERO (5,0,0)
  670 CONTINUE
      IF (MOD(I,9).EQ.0) WRITE (N7,1280) ALPHA,ALPHAQ
      IF (MOD(I,9).EQ.0) WRITE (N7,1660)
      I=I+1
      CALL PARAME (5,IDONE,0,0)
      IF (IDONE.EQ.0) GO TO 670
      WRITE (N22) ((PARAM(K,J),J=1,5),K=1,NREACH)                 **************
C     **************                    END
C
C     ************** READ IN 012 CARDS - REAERATION CONSTANTS **********
      I=0
      CALL ZERO (5,4,0)
680   CONTINUE
      IF (MOD(I,9).EQ.0) WRITE (N7,1280) ALPHA,ALPHAQ
      IF (MOD(I,9).EQ.0) WRITE (N7,1670)
      I=I+1
      CALL PARAME (5,IDONE,4,0)
      IF (IDONE.EQ.0) GO TO 680
      WRITE (N22) ((PARAM(K,J),J=1,5),K-1,NREACH)                 **************
C     **************                    END
C
C     ************** READ IN 013 CARDS - PHOSPHOROUS CONSTANTS *********
      I=0
      CALL ZERO (3,0,0)
      GO TO (690,700,710), MODPHO
690   CONTINUE
      IF (MOD(I,9).EQ.0) WRITE (N7,1280) ALPHA,ALPHAQ
      IF (MOD(I,9).EQ.0) WRITE (N7,1680)
      I=I+1
      CALL PARAME (3,IDONE,0,0)
      IF (IDONE.EQ.0) GO TO 690
      GO TO 720
700   CONTINUE
      IF (MOD(I,9).EQ.0) WRITE (N7,1280) ALPHA,ALPHAQ
      IF (MOD(I,9).EQ.0) WRITE (N7,1690)
      I=I+1
      CALL PARAME (3,IDONE,0,0)
      IF (IDONE.EQ.0) GO TO 700
      GO TO 720
710   CONTINUE
      IF (MOD(I,9).EQ.0) WRITE (N7.1280) ALPHA,ALPHAQ
      IF (MOD(I,9).EQ.0) WRITE (N7,1700)
      I=I+1
      CALL PARAME (3,IDONE,0,0)
      IF (IDONE.EQ.0) GO TO 710
720   WRITE (N22) ((PARAM(K,J),J=1,3),K=1,NREACH)                 **************
C     **************                    END
C
C     ************** READ IN 014 CARDS - NITROGEN CONSTANTS ************
C
      I=0
      CALL ZERO (3,0,0)
      GO TO (730,740), MODTIN
730   CONTINUE
```

```
      IF (MOD(I,9).EQ.0) WRITE (N7,1280) ALPHA,ALPHAQ
      IF (MOD(I,9).EQ.0) WRITE (N7,1710)
      I=I+1
      CALL PARAME (3,IDONE,0,0)
      IF (IDONE.EQ.0) GO TO 730
      GO TO 750
740   CONTINUE
      IF (MOD(I,9).EQ.0) WRITE (N7,1280) ALPHA,ALPHAQ
      IF (MOD(I,9).EQ.0) WRITE (N7,1720)
      I=I+1
      CALL PARAME (3,IDONE,0,0)
      IF (IDONE.EQ.0) GO TO 740
750   WRITE (N22) ((PARAM(K,J),J=1,3),K=1,NREACH)
C     **************                  END                  *************
C
C     ************** READ IN Q15 CARDS  ALGAL              *************
      I=0
      CALL ZERO (17,0,0)
760   CONTINUE
      IF (MOD(I,5).EQ.0) WRITE (N7,1280) ALPHA,ALPHAQ
      IF (MOD(I,5).EQ.0) WRITE (N7,1730)
      I=I+1
      CALL PARAME (17,IDONE,0,0)
      IF (IDONE.EQ.0) GO TO 760
      DO 770 K=1,NREACH
      IF (PARAM(K,3).LE.0.0) PARAM(K,3)=1.0
      IF (PARAM(K,5).LE.0.0) PARAM(K,5)=1.0
      IF (PARAM(K,6).LE.0.0) PARAM(K,6)=1.0
      IF (PARAM(K,7).LE.0.0) PARAM(K,7)=1.0
      IF (PARAM(K,11).LE.0.0) PARAM(K,11)=1.0
770   CONTINUE
      WRITE (N22) ((PARAM(K,J),J=1,17),K=1,NREACH)
C     **************                  END                  *************
C
C
C     **************            READ IN CARD GROUP Q16             *****
C     **************        THE I.C. FOR CONCENTRATIONS            *****
C
      READ (N5,1740) IC
      GO TO (780,800,850), IC
C
C
C     ************** SET THE I.C. FOR CONCENTRATIONS       *************
C     ************** ALL THE SAME                          *************
780   READ (N5,1750) (CONCIC(1,I),I=1,16)
      DO 790 J=2,NJ
      DO 790 I=1,16
790   CONCIC(J,I)=CONCIC(1,I)
      GO TO 870
C     **************               END                     *************
C
C
```

```
C     ************** SET THE I.C.  FOR CONCENTRATIONS       **************
C     ************** AS REACH PARAMETERS
 800  READ (N5,1760) (IRECH(I),I=1,20)
      IF (IRECH(1).EQ.9999) GO TO 870
      READ (N5,1750) (CONC(IL),IL=1,16)
      DO 840 I-1,20
      IREA=IRECH(I)
      IF (IREA.LE.0) GO TO 800
      DO 830 J=1,NJ
      IF (IREA.EQ.IREACH(J)) GO TO 810
      GO TO 830
 810  DO 820 K=1,16
 820  CONCIC(J,K)=CONC(K)
 830  CONTINUE
 840  CONTINUE
      GO TO 800
C     **************            END                         **************
C
C
C     ************** SET THE I.C.  FOR CONCENTRATIONS       **************
C     ************** DIFFERENT FOR EACH NODE                **************
 850  DO 860 J=1,NJ
 860  READ (N5,1750) (CONCIC(J,K),K=1,16)
C     **************            END                         **************
C
 870  CONTINUE
      WRITE (N22) ((CONCIC(J,K),K=1,16),J=1,NJ)
      WRITE (N7,1280) ALPHA,ALPHAQ
      WRITE (N7,1770)
      DO 880 J=1,NJ
      WRITE (N7,1780) J,(CONCIC(J,I),I=1,16)
      I=MOD(J,10)
      IF (J.EQ.NJ) GO TO 880
      IF (I.NE.0) GO TO 880
      WRITE (N7,1280) ALPHA,ALPHAQ
      WRITE (N7,1770)
 880  CONTINUE
C     **************            END                         **************
C
C
C     ************** INPUT THE SOURCE VERSUS TIME FUNCTIONS**************
C
C     ************** INPUT THE CONSTANT SOURCE VALUES       **************
      READ (N5,1790) NCSOUR
      IF (NCSOUR.LE.0) GO TO 930
      IF (NCSOUR.LE.NSOURC) GO TO 890
      WRITE (N6,1800)
      STOP
 890  DO 900 NS=1,NCSOUR
      DO 900 ICN=1,16
      DO 900 I=2,5
 900  A(NS,ICN,I)=0.
```

```
1280  FORMAT (1H1,15A4,20X,20HBATTELLE NORTHWEST  ,/1X,15A4,19X,21H RICH
     1LAND, WASHINGTON,/1X,20A4,20HQUALITY MODEL        ,/)
1285  FORMAT (' NO TIME VARYING HYDRAULIC OR QUALITY DATA HAS BEEN REQUE
     1STED.  THIS WILL BE A STEADY STATE RUN.')
1290  FORMAT (' THIS IS A RESTART OF AN OLD RUN')
1300  FORMAT (40X,'BNW EXPLORE-1 QUALITY MODEL INPUT '//)
1310  FORMAT (' THE ALGAE CALCULATIONS WILL BE PERFORMED.')
1320  FORMAT (' THE ALGAE CALCULATIONS WILL NOT BE PERFORMED.')
1330  FORMAT (' BOTH CARBONACEOUS AND NITROGENOUS BOD ARE CALCULATED.')
1340  FORMAT (' ONLY TOTAL BOD IS CALCULATED.')
1350  FORMAT (' P-R IS PROPORTIONAL TO PHYTOPLANKTON CONCENTRATION.')
1360  FORMAT (' P-R IS NOT PROPORATIONAL TO PHYTOPLANKTON CONCENTRATION'
     1)
1370  FORMAT (' NO P-R EFFECTS ARE CONSIDERED.')
1380  FORMAT (' THE ALGAL NITROGEN MODEL WILL BE USED.')
1390  FORMAT (' ONLY THE AMMONIA NITRATE MODEL WILL BE USED.')
1400  FORMAT (' THE ALGAL PHOSPHOROUS MODEL WILL BE USED.')
1410  FORMAT (' THE PHOSPHOROUS MODEL IS A FIRST ORDER DECAY MODEL.')
1420  FORMAT (' THE PHOSPHOROUS MODEL IS A SECOND ORDER DECAY MODEL.')
1430  FORMAT (' THE GENERAL REAERATION MODEL WILL BE USED.'/)
1440  FORMAT (' THE O-CONNOR--DOBBINS REAERATION MODEL WILL BE USED.'/)
1450  FORMAT (' THE DOBBINS REAERATION MODEL WILL BE USED.'/)
1460  FORMAT (' THE THACKSTON-KRENKEL REAERATION MODEL WILL BE USED.'/)
1470  FORMAT (' THE TIDAL EXCHANGE COEFFICIENT FOR THIS ESTUARY IS'1PE12
     1.5)
1480  FORMAT (' THE FOLLOWING INITIAL INTEGRATION INTERVAL H1= '1PE12.5,
     1' HAS BEEN SELECTED.'/' THE QUALITY MODEL WILL RUN FOR ',I5,' TIDA
     2L CYCLES.'/' THE RIVER AND(OR)ESTUARY SYSTEM HAS BEEN MODELED WITH
     3 ',I5,' NODES AND ',I5,' CHANNELS '//)
1490  FORMAT (' THE MODEL HAS ',I4,' UPSTREAM NODE(S) '/' THEY(IT) ARE(I
     1S) AS FOLLOWS '/20I4/20I4/20I4/20I4/)
1500  FORMAT (/' THE RIVER OR ESTUARY SYSTEM WAS THEN DIVIDED INTO ',I3,
     1' REACH(ES)'/)
1510  FORMAT (/' YOU REQUESTED ',I4,' REACHES.  ( RUN ABORTED )'//)
1520  FORMAT (16I5)
1530  FORMAT (/' THE FOLLOWING JUNCTIONS FORM THE BOUNDARY FOR REACH NUM
     1BER ',I3,/8I10/8I10)
1540  FORMAT (1H1,'THERE IS AN ERROR IN THE ASSIGNMENT OF REACHES '/)
1550  FORMAT (10I10)
1560  FORMAT (' THE FOLLOWING JUNCTIONS ARE IN REACH NUMBER ',I3/)
1570  FORMAT (10I10)
1580  FORMAT (16I5)
1590  FORMAT (' THE',I4,' TERM ARRAY WHICH FOLLOWS '/' REPRESENTS THE JU
     1NCTION NUMBER(S) WHERE THE',I4,' SOURCE(S) ARE ADDED TO THE SYSTEM
     2 '//)
1600  FORMAT (12I5)
1610  FORMAT (23X,'BOD CONSTANTS '//14X,'CARBONACEOUS',16X,'NITROGENOUS'
     1/'   DECAY   SEDIMENT    SCOUR      TEMP       DECAY      TEMP'/'   /
     2DAY        /DAY    MG/L/DAY   COEFF         /DAY    COEFF'/60(1H-))
1620  FORMAT (3X,'BENTHIC CONSTANTS '//'    DECAY     TEMP'/'    /DAY
     1COEFF'/20(1H-))
1630  FORMAT (23X,'TOC CONSTANTS '//'    DECAY   SEDIMENT    PROPR    BIO
      DO 1100 I=1,NSOURC
      DO 1090 K=1,16
1090  VARB(I,K)=0.0
      DO 1100 ICN=1,16
1100  VARB(I,ICN)=A(I,ICN,1)+A(I,ICN,2)*TIME+A(I,ICN,3)*TIME**2+A(I,ICN,
     14)*TIME**3+A(I,ICN,5)*TIME**4
1110  CONTINUE
      DO 1120 I=1,NREACH
1120  TEMPS(I)=TEMP(I,1)+TEMP(I,2)*TIME+TEMP(I,3)*TIME**2+TEMP(I,4)*TIME
     1**3+TEMP(I,5)*TIME**4
      DO 1130 I=1,NJAN
1130  DSOUR(I)=DS(I,1)+DS(I,2)*TIME+DS(I,3)*TIME**2+DS(I,4)*TIME**3+DS(I
     1,5)*TIME**4
      IF (NUPSTR.LE.0) GO TO 1150
      DO 1140 KIL=1,NUPSTR
      DO 1140 KKL=1,16
1140  UPSTR(KIL,KKL,6)=UPSTR(KIL,KKL,1)+UPSTR(KIL,KKL,2)*TIME+UPSTR(KIL,
     1KKL,3)*TIME**2+UPSTR(KIL,KKL,4)*TIME**3+UPSTR(KIL,KKL,5)*TIME**4
1150  CONTINUE
      WRITE (N22) ((VARB(I,J),I=1,NSOURC),J=1,16),(TEMPS(I),I=1,NREACH),
     1(DSOUR(I),I=1,NJAN),((UPSTR(I,J,6),I=1,NUPSTR),J=1,16)
1160  CONTINUE
      END FILE N22
C     **************                 END                  *************
C
C     ************** PRODUCE LINEPRINTER OUTPUT               *************
      WRITE (N7,1900) ASTERK
      REWIND N7
1170  READ (N7,1910) ARRAY
      IF (ARRAY(1).EQ.ASTERK) GO TO 1180
      WRITE (N6,1910) ARRAY
      GO TO 1170
C     **************                 END                  *************
1180  WRITE (N6,1920)
      REWIND N7
C     **************                END                   *************
      RETURN
C
C
C
1190  FORMAT (20A4)
1200  FORMAT (26X,20A4)
1210  FORMAT (1H1)
1220  FORMAT (20A4)
1230  FORMAT (7I5,2F10.0,5I5)
1240  FORMAT (1H1,'YOU REQUESTED ',I5,'REACHES AND THE LIMIT IS ',I5,'RE
     1ACHES  (RUN ABORTED)'//)
1250  FORMAT (1H1,'YOU REQUESTED ',I5,' SOURCES AND THE MAXIMUM ALLOWABL
     1E IS',I5,' SOURCES   (RUN ABORTED) ')
1260  FORMAT (' YOU REQUESTED ',I5,' UPSTREAM NODES AND THE MAXIMUM IS',
     1I5,'(RUN ABORTED) '/)
1270  FORMAT (16I5)
```

```
C     ************** INPUT CONSTANT UPSTREAM NODE CONC.     *************
      IF (NUPSTR.LE.0) GO TO 1080
      READ (N5,1790) NCUPS
      IF (NCUPS.LT.0) NCUPS=0
      NTVUPS=NUPSTR-NCUPS
      IF (NCUPS.LE.0) GO TO 1040
      WRITE (N7,1280) ALPHA,ALPHAQ
      WRITE (N7,1770)
      DO 1030 M=1,NCUPS
      I=IUPSTR(M)
      READ (N5,1750) (UPSTR(I,J,1),J=1,16)
      DO 1010 K=2,6
      DO 1010 J=1,16
1010  UPSTR(I,J,K)=0.0
      KL=MOD(M,10)
      IF (KL.NE.0) GO TO 1020
      WRITE (N7,1280) ALPHA,ALPHAQ
      WRITE (N7,1770)
1020  WRITE (N7,1870) IUP(I),(UPSTR(I,J,1),J=1,16)
1030  CONTINUE
C     **************              END                   *************
C
C     ************** INPUT THE TIME VARYING UPSTREAM NODE  *************
C     **************          CONCENTRATIONS               *************
1040  IST=NCUPS+1
      LST=NCUPS+NTVUPS
      IF (NTVUPS.EQ.0) GO TO 1080
      DO 1070 M=IST,LST
      I=IUPSTR(M)
      WRITE (N7,1280) ALPHA,ALPHAQ
      WRITE (N7,1880) IUP(I)
      DO 1060 J=1,16
      K=J*2-1
      CALL REGRES (ATEMP)
      WRITE (N7,1890) ACON(K),ACON(K+1),IUP(I),(ATEMP(KL),KL=1,5)
      DO 1050 KK=1,5
1050  UPSTR(I,J,KK)=ATEMP(KK)
      UPSTR(I,J,6)=0.0
1060  CONTINUE
1070  CONTINUE
1080  CONTINUE
C     **************    END                              *************
C
C     ************** WRITE OUT THE SOURCE AND TEMPERATURE  *************
C     ************** AS A FUNCTION OF TIME TO THE QUALITY  *************
C     ************** TAPE
      NLAS=NOSWRT+NTQCYC
      DO 1160 NT=NOSWRT,NLAS
      DO 1160 NQ=1,NOCYC
      TIME=FLOAT((NT-NOSWRT)*NOCYC+NQ)*DELTQ/3600.0
      WRITE (N22) NT,NQ
      IF (NSOURC.LE.0) GO TO 1110
      DO 910 NS=1,NCSOUR
910   READ (N5,1010) (A(NS,ICN,1),ICN=1,15)
      WRITE (N7,1280) ALPHA,ALPHAQ
      WRITE (N7,1770)
      DO 920 NS=1,NCSOUR
      WRITE (N7,1820) NS,ISOP(NS),(A(NS,ICN,1),ICN=1,16)
      IH=MOD(NS,14)
      IF (NS.EQ.NCSOUR) GO TO 920
      IF (IH.NE.0) GO TO 920
      WRITE (N7,1280) ALPHA,ALPHAQ
      WRITE (N7,1770)
920   CONTINUE
C     **************              END                  *************
C
930   CONTINUE
      NS1=NCSOUR+1
      IF (NS1.GT.NSOURC) GO TO 960
      DO 950 NS=NS1,NSOURC
      WRITE (N7,1280) ALPHA,ALPHAQ
      WRITE (N7,1830) NS
      DO 950 ICN=1,16
      CALL REGRES (ATEMP)
      IKC=ICN*2-1
      WRITE (N7,1840) ACON(IKC),ACON(IKC+1),ISOP(NS),(ATEMP(I),I=1,5)
      DO 940 I=1,5
940   A(NS,ICN,I)=ATEMP(I)
950   CONTINUE
960   CONTINUE
C     **************             END                   *************
C
C     ************** INPUT THE TEMP.  VERSUS TIME FUNCTIONS *************
      DO 980 IREA=1,NREACH
      KALF=IREA-1
      IF (MOD(KALF,20).EQ.0) WRITE (N7,1280) ALPHA,ALPHAQ
      CALL REGRES (ATEMP)
      WRITE (N7,1850) IREA,(ATEMP(I),I=1,5)
      DO 970 I=1,5
970   TEMP(IREA,I)=ATEMP(I)
980   CONTINUE
C     **************             END                   *************
C
C     ************** INPUT DISSOLVED OXYGEN SOURCE TERMS   *************
      DO 1000 I=1,NJGW
      KALE=I-1
      IF (MOD(KALE,20).EQ.0) WRITE (N7,1280) ALPHA,ALPHAQ
      CALL REGRES (ATEMP)
      WRITE (N7,1860) I,(ATEMP(J),J=1,5)
      DO 990 J=1,5
990   DS(I,J)=ATEMP(J)
1000  CONTINUE
C     **************              END                  *************
C
```

```
     1LOG     REFRAC      TEMP'/'    /DAY       /DAY      COEFF     SCOUR
     2 SCOUR     COEFF'/60(1H-))
1640  FORMAT (17X,'TOXIC CONSTANTS '//'     DECAY      POWER      TEMP'/'
     1CONST'/15X,'COEFF'/30(1H-))
1650  FORMAT (13X,'P-R FOR SUSPENDED ALGAE'//'  CONST1     PERIOD       PHA
     15E     CONST2       PHASE'/23X,'ANGLE1',14X,'ANGLE2'/50(1H-))
1660  FORMAT (13X,'P-R FOR ATTACHED ALGAE'//'  CONST1     PERIOD       PHAS
     1E     CONST2       PHASE'/23X,'ANGLE1',14X,'ANGLE2'/50(1H-))
1670  FORMAT (14X,'REARATION CONSTANTS '//'  CONST1     CONST2     CONST3
     1     TEMP       CONST4'/33X,'COEFF'/50(1H-))
1680  FORMAT (3X,'PHOSPHORUS RATE CONSTANTS'//'  SOL TO     SED TO      ORG
     1 TO'/'    SED          SOL           SOL'/30(1H-))
1690  FORMAT (3X,'PHOSPHORUS RATE CONSTANTS'//'  SOL TO     SED TO'/'    S
     1ED          SOL'/20(1H-))
1700  FORMAT (3X,'PHOSPHORUS RATE CONSTANTS'//'    SOL'/'    DECAY'/10(1H
     1-))
1710  FORMAT (3X,'NITROGEN RATE CONSTANTS'//'  NH3 TO     NO2 TO      ORG T
     10'/'     NO2          NO3           NH3'/30(1H-))
1720  FORMAT (3X,'NITROGEN RATE CONSTANTS'//'  NH3 TO'/'     NO3'110(1H-))
1730  FORMAT (60X,'ALGAL CONSTANTS '//3X,5HPHYTO,5X,5HPHOTO,4X,6HEXTINC,
     14X,7HSAT SUM,3X,7HAVE SUM,3X,6HNTOTAL,7X,3HPO4,5X,5HPHYTO,7X,3HZOO
     2,5X,7HCONVERS,4X,5HPHYTO,4X,'NIT-PHY',3X,'PHO-PHY'/2X,'GROWTH',4X,
     3'PERIOD',5X,'COEFF',3X,'INTENSITY INTENSITY',3X,'CONST',5X,'CONST'
     4,5X,'DEATH',5X,'GRAZING',5X,'EFF',6X,'CONST',5X,'RATIO',5X,'RATIO'
     5/130(1H-)//2X,'NIT-ZOO',3X,'PHO-ZOO',3X,'ZOO-RES',3X,'ZOO-OTHER'/3
     6X,'RATIO',5X,'RATIO',5X,'DEATH',7X,'DEATH'/40(1H-))
1740  FORMAT (I5)
1750  FORMAT (8F10.4)
1760  FORMAT (20I4)
1770  FORMAT (7X,3HBEN,7X,3HSED,7X,3HSOL,7X,3HORG,7X,3HCAR,7X,3HNIT,7X,3
     1HREF,7X,3HTOC,7X,3HNH3,7X,3HNO2,7X,3HNO3/7X,3HBOD,6X,4HPHOS,6X,4HP
     2HOS,6X,4HPHOS,7X,3HBOD,7X,3HBOD,8X,2HOC,/110(1H-)//7X,3HORG,5X,5HT
     3OXIC,5X,5HPHYTO,7X,3HZOO,8X,2HDO/9X,1HN/50(1H-))
1780  FORMAT (' INITIAL CONCENTRATIONS FOR NODE',I4/3X,11(1PE10.4)/3X,11
     1(1PE10.4))
1790  FORMAT (I5)
1800  FORMAT (' YOU REQUESTED MORE CONSTANT SOURCE INPUTS THAN YOU DID S
     1OURCES.  THAT IS A NO NO. ')
1810  FORMAT (8F10.4)
1820  FORMAT (' CONSTANT SOURCE NUMBER',I4,'    IT FEEDS  JUNCTION NUMBER
     1',I4,/3X,11(1PE10.4)/3X,11(1PE10.4))
1830  FORMAT (' THE SOURCE DATA FOR SOURCE NUMBER',I4,' WERE FIT VIA REG
     1RESSION TO THE FOLLOWING POLYNOMIALS'/)
1840  FORMAT (1H ,2A6,' SOURCE.  THE MATERIAL IS ADDED AT NODE',I5,' .
     1THE SOURCE VERSUS TIME CURVE IS FIT BY '/22X,' SOURCE=',1PE10.4,2H
     2+,1PE10.4,7H*TIME +,1PE10.4,10H*TIME**2 +,1PE10.4,10H*TIME**3 +,1P
     3E10.4,8H*TIME**4)
1850  FORMAT (' THE TEMPERATURE VERSUS TIME CURVE FOR REACH NUMBER',I4,'
     1 IS FIT BY '/22X,' TEMPERATURE=',1PE10.4,2H+,1PE10.4,7H*TIME +,1PE
     210.4,10H*TIME**2 +,1PE10.4,10H*TIME**3 +,1PE10.4,8H*TIME**4)
1860  FORMAT (' THE DISSOLVED OXYGEN VERSUS TIME CURVE FOR CONTROLLED NO
     1DE',I4,' IS FIT BY'/22X,' DISS. OXY. =',1PE10.4,2H+,1PE10.4,7H*TIM
     2E +,1PE10 4,10H*TIME**2 +,1PE10.4,10H*TIME**3 +,1PE10.4,8H*TIME**4
     3)
1870  FORMAT (' UPSTREAM NODE ',I4,' CONCENTRATIONS ARE HELD AT THE FOLL
     1OWING VALUES '/2X,11(1PE10.4)/3X,11(1PE10.4))
1880  FORMAT (' UPSTREAM NODE',I4,' HAS THE FOLLOWING TIME VARYING CONCE
     1NTRATIONS')
1890  FORMAT (1H ,2A6,'CONCENTRATION VERUS TIME CURVE FOR UPSTREAM NODE'
     1,I4,' IS FIT BY THE FOLLOWING CURVE '/22X,' SOURCE=',1PE10.4,2H+,1
     2PE10.4,7H*TIME +,1PE10.4,10H*TIME**2 +,1PE10.4,10H*TIME**3 +,1PE10
     3.4,8H*TIME**4)
1900  FORMAT (A4)
1910  FORMAT (33A4)
1920  FORMAT (1H1,'END OF QUALITY INPUT PROGRAM'/)
      END


      SUBROUTINE PARAME (NUMB,IDONE,L,M)                   *************
C     ************** BATTELLE NORTHWEST 11/9/71
C     ***************************************************************************
C
C                                                          *************
C     ************** ASSIGN THE COMMON  DATA
      COMMON /TAPES/N5,N6,N20,N22.N24,N7
      COMMON/PARAMS/IZ1,IZ2,IZ5,IZ6,IZ9,IZ12,IZ13,MAXUPS
C                                                          *************
C     ************** CONTROL AND TITLE INFORMATION
      COMMON /PTINT/ NJ,NC,NJGW,NTCYC.NUSURT,NQCYC,DELTQ,PERIOD,
     1ALPHA(30),DEP(500),IPOINT(500,6),AS(500),EVAP
      COMMON/QUAL/NCHAN(500,6),LEN(600),NJUNC(600,2),JGW(20)
C                                                          *************
C     ************** ASSIGN THE BLANK COMMON DATA
      COMMON IWELL,ARRAY(33),ALPHAQ(20),ALP4(20)
      COMMON IREA,IAK,INEB.ITIMS,IZER,NREACH,MAXREA,IREACH(500),IRBND(16
     1),IRECH(50),PARAM(17,50),PARM(17),TEMP(50,5),TEMPS(50)
      COMMON ISTART,MODEL,MODREA,MODPHO,MODTIN,H1
      COMMON NSOURC,MAXSOR,ISOP(50),VARB(50,16),A(50,16,5),NCONC,ICN
     1,NCN,TIME
      COMMON ATEMP(10)
      COMMON DSOUR(20),DS(20,5)
      COMMON CONCIC(500,16),CONC(16)
C
      REAL LEN
```

```
C
      READ (N5,140) (IRECH(I),I=1,20)
C     ************** WAS A QEND CARD READ                    *************
      IDONE=0
      IF (IRECH(1).LT.9999) GO TO 100
      IDONE=1
      RETURN
100   READ (N5,150) (PARM(I),I=1,NUMB)
      DO 120 I=1,20
      IREA=IRECH(I)
      IF (IREA.LE.0) GO TO 130
      DO 120 K=1,NUMB
      IF ((K.EQ.L).OR.(K.EQ.M)) GO TO 110
      GO TO 120
110   IF (PARM(K).GT.0) GO TO 120
      PARM(K)=1.0
      WRITE (N7,160) K
120   PARAM(IREA,K)=PARM(K)
      I=21
130   IEND=I-1
      WRITE (N7,170) (IRECH(I),I=1,IEND)
      WRITE (N7,180) (PARM(J),J=1,NUMB)
      RETURN
C
C


      FUNCTION SORDER(FIRST,SECOND)
      DIMENSION FIRST(3),SECOND(3)
      SORDER=FIRST(2)-SECOND(2)
      RETURN
      END


C
140   FORMAT (20I4)
150   FORMAT (8F10.4)
160   FORMAT (' DEFAULT VALUES ASSUMED FOR PARAMETER',I4)
170   FORMAT (' REACH(ES)'/20I5)
180   FORMAT (13(1PE10.3)/13(1PE10.3)/)
      END
      SUBROUTINE ZERO (NUMB,L,M)
C     ************** BATTELLE NORTHWEST 11/9/71             *************
C     *******************************************************************
C
C
C     ************** ASSIGN THE COMMON  DATA                *************
      COMMON /TAPES/N5,N6,N20,N22,N24,N7
      COMMON/PARAMS/IZ1,IZ2,IZ5,IZ6,IZ9,IZ12,IZ13,MAXUPS
C
C     ************** CONTROL AND TITLE INFORMATION          *************
      COMMON /PTINT/ NJ,NC,NJCM,NTCYC,NOSWPT,NOCYC,DELTA,PERIOD,
     1ALPHA(30),DEP(500),IPOINT(500,6),AS(500),EVAP
      COMMON/DUAL/NCHAN(500,6),LEN(600),NJUNC(600,2),JGW(20)
C
C     ************** ASSIGN THE BLANK COMMON DATA            *************
      COMMON IWELL,ARRAY(33),ALPHA0(20),ALPH(20)
      COMMON IREA,IAK,INKB,ITIMS,IZER,NREACH,MAXREA,IREACH(500),IRSND(16
     1),IRECH(50),PARAM(17,50),PARM(17),TEMP(50,5),TEMPS(50)
      COMMON ISTART,MODEL,MODREA,MODPHO,MODTIN,H1
      COMMON NSOURC,MAXSOR,ISOP(50),VAPB(50,16),A(50,16,5),NCONC,ICN
     1,NCN,TIME
      COMMON ATEMP(10)
      COMMON DSOUR(20),DS(20,5)
      COMMON CONCIC(500,16),CUNC(16)
C
      REAL LEN
C
      DO 100 I=1,NUMB
      DO 100 J=1,NREACH
      PARAM(J,I)=0.
      IF ((I.EQ.L).OR.(I.EQ.M)) PARAM(J,1)=1.0
100   CONTINUE
      RETURN
      END
```

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```
      SUBROUTINE SORT (M,N,ITEM,Q)
C
C     ALGORITHM 245 -  TREESORT 3   FROM ACM, DEC. 1964
C                                         VOL 7   NUMBER 12, PAGE 701
C
C     PROGRAMMED BY JE SCHLOSSER
C
C
C     GENERAL PURPOSE INTERNAL SORT SUBROUTINE
C
C     EXAMPLE OF USE - - -   ASSUME -   N ITEMS OF 5 WORDS EACH
C                                       TO BE SORTED IN ASCENDING
C                                       ORDER ON THE SECOND WORD.
C     MAIN PROGRAM
C     DIMENSION A(5,1000)    N IS LESS THAN OR EQUAL TO 1000
C                            A CONTAINS THE ITEMS TO BE SORTED
C
C     EXTERNAL Q          Q IS A FUNCTION SUBROUTINE WHICH WILL RETURN
C      .                  A POSITIVE NUMBER IF THE FIRST ITEM (FIRST
C      .                  ARGUMENT) IS TO SORT AHEAD OF THE  SECOND
C      .                  ITEM (SECOND ARGUMENT).    SEE EXAMPLE BELOW.
C
C     CALL SORT (A,N,5,Q)   ARGUMENT      MEANING
C      .                     FIRST        ARRAY CONTAINING ITEMS
C      .                     SECOND       NUMBER OF ITEMS
C      .                     THIRD        NUMBER OF WORDS PER ITEM
C      .                     FOURTH       FUNCTION SUBROUTINE TO
C      .                                        DEFINE SORT ORDER
C
C     FUNCTION Q(B,C)          WRITE A FUNCTION SUBROUTINE SUCH AS THIS.
C     DIMENSION B(5),C(5)      IT SHOULD RETURN A POSITIVE RESULT IF
C     Q=C(2)-B(2)              THE FIRST ARGUMENT SHOULD SORT AHEAD
C     RETURN                   OF THE SECOND ARGUMENT.   THIS ROUTINE
C     END                      PRODUCES AN ASCENDING SORT ON THE SECOND
C                              WORD  OF THE ITEMS.
C
C     NOTE - -  THE MAXIMUM NUMBER OF WORDS PER ITEM IS LIMITED
C     BY THE DIMENSION OF KOPY.      THIS LIMIT IS PRESENTLY 100.
C
C     APPROXIMATE SPEED IS 250 ITEMS PER SECOND.
      INTEGER Q
      DIMENSION KOPY (100)
      DIMENSION M(ITEM,N)
      IF (N-1) 320,320,100
100   K=N/2+1
      L=N/2-1
      IF (L) 210,210,110
110   CONTINUE
      DO 200 II=1,L
      I=K-II
      JJ=I
      NS=N
      DO 120 IQ=1, ITEM
120   KOPY(IQ)-M(IQ, IS)
130   J=2*IS
      IF (J. GT. NS) GO TO 180
      IF (J. GE. NS) GO TO 150
      IF (Q(M(1, J+1), M(1, J))) 140, 150, 150
140   J=J+1
150   IF (Q(M(1, J), KOPY)) 160, 180, 180
160   DO 170 IQ=1, ITEM
170   M(IQ, IS)=M(IQ, J)
      IS=J
      GO TO 130
180   DO 190 IQ=1, ITEM
190   M(IQ, IS)=KOPY(IQ)
200   CONTINUE
210   NPLUS=N+2
      DO 310 II=2, N
      I=NPLUS-II
      IS=1
      NS=I
      DO 220 IQ=1, ITEM
220   KOPY(IQ)=M(IQ, IS)
230   J=2*IS
      IF (J. GT. NS) GO TO 280
      IF (J. GE. NS) GO TO 250
      IF (Q(M(1, J+1), M(1, J))) 240, 250, 250
240   J=J+1
250   IF (Q(M(1, J), KOPY)) 260, 280, 280
260   DO 270 IQ=1, ITEM
270   M(IQ, IS)=M(IQ, J)
      IS=J
      GO TO 230
280   DO 290 IQ=1, ITEM
290   M(IQ, IS)=KOPY(IQ)
      DO 300 IT=1, ITEM
      LAZY=M(IT, 1)
      M(IT, 1)=M(IT, I)
      M(IT, I)=LAZY
300   CONTINUE
310   CONTINUE
320   CONTINUE
      RETURN
      END
      SUBROUTINE REGRES (ATEMP)
C
      COMMON /TAPES/N5,N6,N7,N18,N20,N22,N24
C        POLYNOMIAL REGRESSION WITH PLOTTING.
C
C        THIS MAIN PROGRAM READS THE HORIZONTAL AND VERTICAL COORDINATES
C        OF M DATA POINTS INTO THE X AND Y ARRAYS.   THE LEAST AND
C        GREATEST VALUES OF X SHOULD BE STORED IN X(1) AND X(M) RESPEC-
C        TIVELY.   THE FUNCTION REGR IS USED TO PERFORM SUCCESSIVE NTH-
C        ORDER REGRESSIONS, FROM N = MIN THROUGH N = MAX.   IN EACH
C        CASE, THE REGRESSION CURVE IS PLOTTED AGAINST THE ORIGINAL
C        DATA POINTS.
C
C     A.......REGRESSION COEFFICIENT(INTERCEPT)
C     B.......VECTOR CONTAINING REGRESSION COEFFICIENTS
C     DELTAX...X-SPACING FOR 26 POINTS ON THE REGRESSION CURVE
C     M.......NUMBER OF DATA POINTS
C     MAX,MIN..UPPER AND LOWER LIMITS ON ORDER OF REGRESSION
C     N.......ORDER, N, OF POLYNOMIAL REGRESSION
C     REGR....FUNCTION FOR PERFORMING NTH ORDER REGRESSION
C     S.......STANDARD DEVIATION OF THE POINTS ABOUT THE REGRESSION
C             LINE.  IF SIMUL ENCOUNTERS A NEAR-SINGULAR MATRIX, S IS
C             RETURNED ZERO AS A WARNING.
C     X,Y.....VECTORS CONTAING THE X AND Y COORDINATES OF THE DATA
C             POINTS.
C
      DIMENSION ARRAY(50)
      DIMENSION X(100),Y(100),B(55),ARK(100),ISYM(5),CARD4(13)
      DIMENSION ATEMP(10)
      NAMELIST /CARD1/ M,MIN,MAX,X,Y
      DATA  STAR/1H*/
      DATA ASTER/6H******/CONST/6H CONST/
      DATA/ARRAY/1H1,1H2,1H3,1H4,1H5,1H6,1H7,1H8,1H9,2H10,2H11,2H12,2H13
     1,2H14,2H15,2H16,2H17,2H18,2H19,2H20,2H21,2H22,2H23,2H24,2H25,2H26,
     22H27,2H28,2H29,2H30,2H31,2H32,2H33,2H34,2H35,2H36,2H37,2H38,2H39,2
     3H40,2H41,2H42,2H43,2H44,2H45,2H46,2H47,2H48,2H49,2H50/
      DATA MMM/100/NN/55/III/25/JJJ/100/
C
C     ..... CARD1 IS TITLE CARD FOR PLOTTING .....
C     ..... READ AND CHECK COORDINATES X(1)...X(M), Y(1)...Y(M),
C           AND LOWEST AND HIGHEST REGRESSION ORDERS MIN AND MAX .....
C
      A=0.0
      DO 100 I=1,NN
100   B(I)=0.0
      READ (N5,310) CARD4
      WRITE (6,310) CARD4
      IF (CARD4(1).NE.CONST) GO TO 110
      DECODE (CARD4(2),220) A
      GO TO 200
110   READ (N5,CARD1,ERR=211,END=212)
```

```
      IF (MAX.LT.MIN) MAX=MIN
      IF (MIN.GE.(M-1)) GO TO 120
      IF (MAX.GE.(M-1)) MAX=M-1
      GO TO 130
120   MAX=M-1
      MIN=MAX
130   CONTINUE
      IF (MIN.LE.0) MIN=1
      IF (MAX.LE.0) MAX=1
      IF (CARD4(13).EQ.ASTER) GO TO 140
C
      WRITE (6,260) M,(X(I),Y(I),I=1,M)
      WRITE (6,270) MIN,MAX
140   CONTINUE
      DO 150 I=1,M
150   ARK(I)=STAR
      ISYM(1)=STAR
      DO 190 N=MIN,MAX
      IF (CARD4(13).EQ.ASTER) GO TO 160
      WRITE (6,250) CARD4
      WRITE (6,280) N
160   CONTINUE
C
C     ..... USE FUNCTION REGR TO PERFORM NTH-ORDER REGRESSION .....
C
      S=REGR(M,X,Y,N,A,B)
      IF (S.NE.0.0) GO TO 170
      WRITE (6,290) CARD4
      GO TO 190
170   CONTINUE
      IF (CARD4(13).EQ.ASTER) GO TO 190
      WRITE (6,300) S,A,(I,B(I),I=1,N)
C
C     ..... COMPUTE 25 POINTS LYING ON REGRESSION CURVE .....
C
      DELTAX=(X(M)-X(1))/25.0
      MP1=M+1
      MP26=M+26
      DO 180 I=MP1,MP26
      STEPS=FLOAT(I)-FLOAT(M)-1.0
      X(I)=X(1)+STEPS*DELTAX
      Y(I)=A
      ARK(I)=ARRAY(N)
      DO 180 J=1,N
180   Y(I)=Y(I)+B(J)*X(I)**J
      ISYM(2)=ARRAY(N)
C
C     ..... PLOT REGRESSION CURVE AGAINST ORIGINAL POINTS .....
C
      CALL PICTUR (M+26,III,JJJ,X,Y,ARK,ISYM,CARD4)
190   CONTINUE
200   CONTINUE
```

```
      ATEMP(1)=A
      DO 210 I=2,10
210   ATEMP(I)=B(I-1)
      RETURN
211   WRITE (6,230) CARD4
      STOP
212   WRITE (6,240) CARD4
      STOP
C
C     ..... FORMATS FOR INPUT AND OUTPUT STATEMENTS .....
C
C
C
220    FORMAT (F12.1)
230    FORMAT (' ERROR IN NAMELIST INPUT TO REGRES '/,13A6)
240    FORMAT (' END OF FILE ENCOUNTERED IN REGRES '/,13A6)
250    FORMAT (1H ,13A6)
260    FORMAT (34H  POLYNOMIAL REGRESSION, WITH M = ,I2,12H DATA POINTS//
      18X,5H X(I),8X,5H Y(I)//(2F13.2))
270    FORMAT (58H0 THE LOWEST AND HIGHEST ORDER POLYNOMIALS TO BE TRIED
      1ARE//6X,7H MIN = ,I3,5X,7H MAX = ,I3)
280    FORMAT (32H  POLYNOMIAL REGRESSION OF ORDER/1H0,5X,7H N   = ,I3)
290    FORMAT (69H0 MATRIX C IS NEAR-SINGULAR.   REGRESSION COEFFICIENTS
      1NOT DETERMINED/1H 13A6)
300    FORMAT (1H0,5X,5H S = ,F10.6/6X,5H A = ,F10.6//(6X,3H B(,I2,4H) =
      1,F11.6))
310    FORMAT (13A6)
       END
      FUNCTION SIMUL( N, A, X, EPS, INDIC, NRC )
C
C        WHEN INDIC IS NEGATIVE, SIMUL COMPUTES THE INVERSE OF THE N BY
C        N MATRIX A IN PLACE.  WHEN INDIC IS ZERO, SIMUL COMPUTES THE
C        N SOLUTIONS X(1)...X(N) CORRESPONDING TO THE SET OF LINEAR
C        EQUATIONS WITH AUGMENTED MATRIX OF COEFFICIENTS IN THE N BY
C        N+1 ARRAY A AND IN ADDITION COMPUTES THE INVERSE OF THE
C        COEFFICIENT MATRIX IN PLACE AS ABOVE.  IF INDIC IS POSITIVE,
C        THE SET OF LINEAR EQUATIONS IS SOLVED BUT THE INVERSE IS NOT
C        COMPUTED IN PLACE. THE GAUSS-JORDAN COMPLETE ELIMINATION METHOD
C        IS EMPLOYED WITH THE MAXIMUM PIVOT STRATEGY.  ROW AND COLUMN
C        SUBSCRIPTS OF SUCCESSIVE PIVOT ELEMENTS ARE SAVED IN ORDER IN
C        THE IROW AND JCOL ARRAYS RESPECTIVELY.  K IS THE PIVOT COUNTER,
C        PIVOT THE ALGEBRAIC VALUE OF THE PIVOT ELEMENT, MAX
C        THE NUMBER OF COLUMNS IN A AND DETER THE DETERMINANT OF THE
C        COEFFICIENT MATRIX.  THE SOLUTIONS ARE COMPUTED IN THE (N+1)TH
C        COLUMN OF A AND THEN UNSCRAMBLED AND PUT IN PROPER ORDER IN
C        X(1)...X(N) USING THE PIVOT SUBSCRIPT INFORMATION AVAILABLE
C        IN THE IROW AND JCOL ARRAYS.  THE SIGN OF THE DETERMINANT IS
C        ADJUSTED, IF NECESSARY, BY DETERMINING IF AN ODD OR EVEN NUMBER
C        OF PAIRWISE INTERCHANGES IS REQUIRED TO PUT THE ELEMENTS OF THE
C        JORD ARRAY IN ASCENDING SEQUENCE WHERE JORD(IROW(I)) = JCOL(I).
C        IF THE INVERSE IS REQUIRED, IT IS UNSCRAMBLED IN PLACE USING
C        Y(1)...Y(N) AS TEMPORARY STORAGE.  THE VALUE OF THE DETERMINANT
C        IS RETURNED AS THE VALUE OF THE FUNCTION.  SHOULD THE POTENTIAL
C        PIVOT OF LARGEST MAGNITUDE BE SMALLER IN MAGNITUDE THAN EPS,
C        THE MATRIX IS CONSIDERED TO BE SINGULAR AND A TRUE ZERO IS
C        RETURNED AS THE VALUE OF THE FUNCTION.
C
C     A........AUGMENTED MATRIX OF COEFFICIENTS, A=(AIJ)
C     DETER....DETERMINANT OF THE ORIGINAL COEFFICIENT MATRIX
C     EPS......MINIMUM ALLOWABLE MAGNITUDE FOR A PIVOT ELEMENT
C     I,J......ROW AND COLUMN SUBSCRIPTS,RESP.
C     INDIC....COMPUTATIONAL SWITCH
C     MAX......NUMBER OF COLUMNS IN A,EITHER N OR N+1
C     N........NUMBER OF ROWS IN A
C     X........VECTOR OF SOLUTIONS
C
C     AIJCK....AIC(K)
C     INTCH....NUMD
C     INTCH....NUMBER OF PAIRWISE INTERCHANGES REQ'D TO ORDER J-VECTOR
C     IP1,KM1,NM1...I+1, K-1, AND N-1, RESP.
C     IROW.....VECTOR OF PIVOT ELEMENT ROW SUBSCRIPTS, R(K)
C     ICOL.....VECTOR OF PIVOT ELEMENT COLUMN SUBSCRIPTS, C(K)
C     IROWI,IROWJ,IROWK
C     JCOLI,JCOLJ,JCOLK...R(I),R(J),R(K),C(I),C(J),C(K), RESP.
C     ISCAN,JSCAN...INDICES USED IN PIVOT SEARCH OF VECTORS C AND R
C     JORD.....THE J VECTOR
C     JTEMP....TEMPORARY VARIABLE USED IN ORDERING THE J VECTOR
C     K........CYCLE COUNTER AND PIVOT ELEMENT SUBSCRIPT
C     NRC......ROW AND COLUMN DIMENSIONS OF STORAGE FOR THE A-MATRIX
```

```
C       PIVOT....PIVOT ELEMENT
C       Y.......VECTOR USED IN UNSCRAMBLING THE INVERSE MATRIX
C
        DIMENSION IROW(50),JCOL(50),JORD(50),Y(50),A(NRC,NRC),X(50)
C
        MAX=N
        IF (INDIC.GE.0) MAX=N+1
C
C       .....IS N LARGER THAN 50 .....
        IF (N.LE.50) GO TO 100
        WRITE (6,250)
        SIMUL=0.
        RETURN
C
C       ..... BEGIN ELIMINATION PROCEDURE .....
100     DETER=1.
        DO 170 K=1,N
        KM1=K-1
C
C       ..... SEARCH FOR THE PIVOT ELEMENT .....
        PIVOT=0.
        DO 130 I=1,N
        DO 130 J=1,N
C       ..... SCAN IROW AND JCOL ARRAYS FOR INVALID PIVOT SUBSCRIPTS .....
        IF (K.EQ.1) GO TO 120
        DO 110 ISCAN=1,KM1
        DO 110 JSCAN=1,KM1
        IF (I.EQ.IROW(ISCAN)) GO TO 130
110     IF (J.EQ.JCOL(JSCAN)) GO TO 130
120     IF (DABS(A(I,J)).LE.DABS(PIVOT)) GO TO 130
        PIVOT=A(I,J)
        IROW(K)=I
        JCOL(K)=J
130     CONTINUE
C
C       ..... INSURE THAT SELECTED PIVOT IS LARGER THAN EPS .....
        IF (DABS(PIVOT).GT.EPS) GO TO 140
        SIMUL=0.
        RETURN
C
C       ..... UPDATE THE DETERMINANT VALUE .....
140     IROWK=IROW(K)
        JCOLK=JCOL(K)
        DETER=DETER*PIVOT
C
C       ..... NORMALIZE PIVOT ROW ELEMENTS .....
        DO 150 J=1,MAX
150     A(IROWK,J)=A(IROWK,J)/PIVOT
C
C       ..... CARRY OUT ELIMINATION AND DEVELOP INVERSE .....
        A(IROWK,JCOLK)=1./PIVOT
        DO 170 I=1,N
```

```
      AIJCK=A(I,JCOLK)
      IF (I.EQ.IROWK) GO TO 170
      A(I,JCOLK)=-AIJCK/PIVOT
      DO 160 J=1,MAX
  160 IF (J.NE.JCOLK) A(I,J)=A(I,J)-AIJCK*A(IROWK,J)
  170 CONTINUE
C
C     ..... ORDER SOLUTION VALUES (IF ANY) AND CREATE JORD ARRAY .....
      DO 180 I=1,N
      IROWI=IROW(I)
      JCOLI=JCOL(I)
      JORD(IROWI)=JCOLI
  180 IF (INDIC.GE.0) X(JCOLI)=A(IROWI,MAX)
C
C     ..... ADJUST SIGN OF DETERMINANT .....
      INTCH=0
      NM1=N-1
      DO 190 I=1,NM1
      IP1=I+1
      DO 190 J=IP1,N
      IF (JORD(J).GE.JORD(I)) GO TO 190
      JTEMP=JORD(J)
      JORD(J)=JORD(I)
      JORD(I)=JTEMP
      INTCH=INTCH+1
  190 CONTINUE
      IF (INTCH/2*2.NE.INTCH) DETER=-DETER
C
C     ..... IF INDIC IS POSITIVE RETURN WITH RESULTS .....
      IF (INDIC.LE.0) GO TO 200
      SIMUL=DETER
      RETURN
C
C     ..... IF INDIC IS NEGATIVE OR ZERO, UNSCRAMBLE THE INVERSE
C           FIRST BY ROWS .....
  200 DO 220 J=1,N
      DO 210 I=1,N
      IROWI=IROW(I)
      JCOLI=JCOL(I)
  210 Y(JCOLI)=A(IROWI,J)
      DO 220 I=1,N
  220 A(I,J)=Y(I)
C     ..... THEN BY COLUMNS .....
      DO 240 I=1,N
      DO 230 J=1,N
      IROWJ=IROW(J)
      JCOLJ=JCOL(J)
  230 Y(IROWJ)=A(I,JCOLJ)
      DO 240 J=1,N
  240 A(I,J)=Y(J)
C
C     ..... RETURN FOR INDIC NEGATIVE OR ZERO .....
```

```
      SINUL=DETER
      RETURN
C
C     ..... FORMAT FOR OUTPUT STATEMENT .....
C
C
C
250   FORMAT (10H0N TOO BIG)
      END
      SUBROUTINE PICTUR (N,M,MCOL,XX,YY,ARK,ISYM,CARD1)
C     PROGRAMMED BY JE SCHLOSSER  1965  MODIFIED BY CA OSTER  1966
C     PRESENTS A PICTURE OF DATA ON PRINTED OUTPUT, TWO OPTIONS BEING
C     AVAILABLE
C        1   MCOL POSITIVE
C        2   MCOL NEGATIVE, IN WHICH CASE XINCREMENTS ARE THKEN AS EQUAL
C             TO Y INCREMENTS AS DETERMINED BY M
C
C     DICTIONARY
C
C        VARIABLE   DEFINITION
C           N       NUMBER OF POINTS TO PLOT      (MAXIMUM OF 500)
C           M       MAXIMUM NUMBER OF LINES
C           MCOL    MAXIMUM NUMBER OF COLUMNS
C
C         XX(I)     X COORDINATE FOR ITH POINT
C         YY(I)     Y COORDINATE FOR ITH POINT
C         ARK(I)    MARKER FOR ITH POINT
C         ISYM(I)   PRIORITY DESIGNATOR FOR MARKER USED ON I-TH POINT
C                         (LOWER SUBSCRIPT INDICATES HIGHER PRIORITY)
C
C
      DIMENSION XX(2),YY(2),XYM(3,500),PX(6),ALF(107),ARK(2),
     1ILF(107),ISYM(5),IXYM(3,500)
      DIMENSION CARD1(13)
      EQUIVALENCE (ILF,ALF),(BLANK,LANKBA),(IXYM,XYM)
C
      DATA BLANK/1H  /
C
      EXTERNAL SORDER
      N=MAX0(MIN0(500,N),2)
      XYM(1,2)=1.01
      XYM(2,2)=1.01
      XYM(3,2)=BLANK
      XMIN=1.0E37
      XMAX=-1.0E37
      DO 100 I=1,N
      XYM(1,I)=XX(I)
      XYM(2,I)=YY(I)
      XYM(3,I)=ARK(I)
      XMIN=AMIN1(XMIN,XYM(1,I))
      XMAX=AMAX1(XMAX,XYM(1,I))
100   CONTINUE
      CALL SORT (XYM,N,3,SORDER)
      YMIN=XYM(2,N)
      YMAX=XYM(2,1)
      DYLOG=ALOG10(10./FLOAT(M)*1.0E5)
      IF ((YMAX-YMIN).EQ.0.) GO TO 110
      DYLOG=ALOG10((YMAX-YMIN)/FLOAT(M)*1.0E5)
110   CONTINUE
      APROX=DYLOG-AINT(DYLOG)
      DO 120 I=2,10
      FI=I
      IF (APROX-ALOG10(FI)) 130,130,120
120   CONTINUE
130   EXACT=FI*10. 0**(INT(DYLOG)-5)
      IF (MCOL) 200,140,140
140   DXLOG=ALOG10((XMAX-XMIN)/FLOAT(MCOL/2)*1. 0E5)
      XAPROX=DXLOG-AINT(DXLOG)
      IF (XAPROX-. 3010) 150,150,160
150   XEXACT=2. 0*10. 0**(INT(DXLOG)-5)
      GO TO 190
160   IF (XAPROX-. 6990) 170,170,180
170   XEXACT=5. 0*10. 0**(INT(DXLOG)-5)
      GO TO 190
180   XEXACT=10. 0**(INT(DXLOG)-4)
190   CONTINUE
      XACT=XEXACT/2. 0
      GO TO 210
200   XACT=EXACT/2. 0
210   TENX=20. 0*XACT
      TENE=10. 0*EXACT
      MAXYI=(YMAX/TENE)+(0. 5+SIGN(0. 5,YMAX))
      MAXXI=(XMAX/TENX)+(0. 5+SIGN(0. 5,XMAX))
      MINYI=(YMIN/TENE)-(0. 5+SIGN(0. 5,-YMIN))
      MINXI=(XMIN/TENX)-(0. 5+SIGN(0. 5,-XMIN))
      YFIRST=TENE*FLOAT(MAXYI)
      XFIRST=TENX*FLOAT(MINXI)
      LINES=10*(MAXYI-MINYI)+1
      KOLS=20*(MAXXI-MINXI)
      IF (KOLS-500) 230,230,220
220   WRITE (6,490) KOLS
      KOLS=500
230   IF (LINES-401) 250,250,240
240   WRITE (6,500)
      RETURN
250   CONTINUE
      LEAF=(KOLS+99)/100
      DO 430 L=1,LEAF
      DO 260 I=1,6
      PX(I)=5. *TENX*FLOAT(L-1)+TENX*FLOAT(I-1)+XFIRST
260   CONTINUE
      WRITE (6,440) CARD1
      WRITE (6,480) PX
      WRITE (6,470)
      DEX=XACT/2. 0
      DEL=EXACT/2. 0
      DDD=DEX+2. 0*XACT
      J=1
      DO 420 I=1,LINES
      YPLOT=YFIRST-EXACT*FLOAT(I-1)
      DO 270 JKL=1,107
270   ALF(JKL)=BLANK
```

```
280   IF (J-N) 290,290,380
290   IF (XYM(1,J)-PX(1)) 370,300,300
300   CONTINUE
      IF (XYM(2,J)-(YPLOT+DEL)) 310,310,380
310   IF (XYM(2,J)-(YPLOT-DEL)) 380,320,320
320   CONTINUE
      IF (XYM(1,J)-PX(6)-DDD) 330,330,370
330   CONTINUE
      KOL=INT((XYM(1,J)+DEX-PX(1))/XACT)+4
      IF ((KOL.GT.107).OR.(KOL.LT.1)) GO TO 370
      IXYM3J=IXYM(3,J)
      ILFKOL=ILF(KOL)
      IF (ILFKOL.EQ.LANKBA) GO TO 360
      ISYM1=0
      ISYM2=0
      DO 340 IIYY=1,5
      IF (ILFKOL.EQ.ISYM(IIYY)) ISYM1=IIYY
      IF (IXYM3J.EQ.ISYM(IIYY)) ISYM2=IIYY
340   CONTINUE
      ISYMM=MIN0(ISYM1,ISYM2)
      IF (ISYMM) 370,370,350
350   ILF(KOL)=ISYM(ISYMM)
      GO TO 370
360   ALF(KOL)=XYM(3,J)
370   J=J+1
      GO TO 280
380   CONTINUE
      IF (MOD(I-1,10).NE.0) GO TO 390
      WRITE (6,450) YPLOT,ALF
      GO TO 410
390   IF (MOD(I-1,5).NE.0) GO TO 400
      WRITE (6,510) ALF
      GO TO 410
400   WRITE (6,460) ALF
410   CONTINUE
420   CONTINUE
      WRITE (6,470)
      WRITE (6,480) PX
430   CONTINUE
      RETURN
C
C
C
440    FORMAT (///////10X,13A6///)
450    FORMAT (1XF9.3,2H *107A1,1H*)
460    FORMAT (11X1HI107A1,1HI)
470    FORMAT (1H014X1H*5(20H - - - - + - - - - - *)/1H )
480    FORMAT (11XF7.2,5(13XF7.2))
490    FORMAT (45H0ONLY THE FIRST 500 COLUMNS OF A PLOT REQUIRING I3,25H
      1COLUMNS WILL BE PRINTED.)
500    FORMAT (69H0NOBODY IN THEIR RIGHT MIND WOULD WANT A PLOT OF MORE T
      1HAN 400 LINES.)
```

```
 510    FORMAT (11X1H+107A1,1H+)
        END


        FUNCTION REGR (M, X, Y, N, A, B )
 C         FUNCTION REGR, WHICH CARRIES OUT AN NTH-ORDER POLYNOMIAL
 C         REGRESSION ON M DATA POINTS CONTAINED IN THE X AND Y ARRAYS.
 C         THE FUNCTION NORMALLY RETURNS THE STANDARD DEVIATION S OF THE
 C         POINTS ABOUT THE REGRESSION CURVE.   THE REGRESSION COEFFICIENTS
 C         ARE PLACED IN A AND B(1)...B(N).    HOWEVER, IF THE SIMULTANEOUS
 C         EQUATION SOLVING ROUTINE SIMUL ENCOUNTERS A NEAR-SINGULAR
 C         MATRIX, THE FUNCTION RETURNS THE VALUE 0.0
 C
 C      C........MATRIX CONTAINING THE COEFFICIENTS
 C      CYX......C(I,Y) VECTOR
 C      CYY......C(Y,Y) VECTOR
 C      DET......DETERMINANT OF THE COEFFICIENT MATRIX C.
 C      EPS......TOLERANCE USED BY THE FUNCTION SIMUL
 C      SIMUL....FUNCTION FOR SOLVING SIMULTANEOUS EQUATIONS
 C      SX,SYX...VECTOR CONTAINING SUMMATIONS X**I AND X**I * Y
 C      SY,SYY...VECTOR CONTAINING SUMMATIONS Y AND Y**2
 C
        DIMENSION C(51,51),SX(100),SYX(51),CYX(51),X(100),Y(100),B(51)
        DATA EPS/ 1.0E-20/
        DATA MM/100/NN/51/
 C
 C      .....  COMPUTE SUMS OF POWERS AND PRODUCTS .....
        NTWO=2*N
        NP1=N+1
        SY=0.0
        SYY=0.0
        DO 100 I=1,N
        NPI=N+I
        SX(I)=0.0
        SX(NPI)=0.0
 100    SYX(I)=0.0
        DO 120 I=1,M
        SY=SY+Y(I)
        SYY=SYY+Y(I)**2
        DUM=1.0
        DO 110 J=1,N
        DUM=DUM*X(I)
        SX(J)=SX(J)+DUM
 110    SYX(J)=SYX(J)+Y(I)*DUM
        DO 120 J=NP1,NTWO
        DUM=DUM*X(I)
 120    SX(J)=SX(J)+DUM
```

```
C
C     ..... COMPUTE COEFFICIENTS C(I,J) .....
      FM=FLOAT(M)
      CYY=SYY-SY*SY/FM
      DO 130 I=1,N
      CYX(I)=SYX(I)-SY*SX(I)/FM
      C(I,NP1)=CYX(I)
      DO 130 J=1,N



      IPJ=I+J
130   C(I,J)=SX(IPJ)-SX(I)*SX(J)/FM
C
C     ..... CALL ON SIMUL TO SOLVE SIMULTANEOUS EQUATIONS .....
      DET=SIMUL(N,C,B,EPS,1,NN)
      WRITE (6,160) DET
      IF (DET.NE.0.0) GO TO 140
      REGR=0.0
      RETURN
C
C     ..... COMPUTE INTERCEPT A AND STANDARD DEVIATION S .....
140   DUM=SY
      TEMP=CYY
      DO 150 I=1,N
      DUM=DUM-B(I)*SX(I)
150   TEMP=TEMP-B(I)*CYX(I)
      A=DUM/FM
      DENOM=FLOAT(M)-FLOAT(N)-1.0
      S=ABS(TEMP/DENOM)
      S=DSQRT(S)
      IF (S.EQ.0.) S=EPS
      REGR=S
      RETURN
C
C
C
160   FORMAT (13H0      DET = ,E14.8)
      END

      FUNCTION Q(B,C)
      DIMENSION B(5), C(5)
      Q=C(2)-B(2)
      RETURN
      END
```

FIGURE C-31. LISTING OF THE QUALITY CALCULATIONAL COMPUTER PROGRAM FOR EXPLORE-I

```
C     PROGRAM CLEAN
C      CLEAN  A PROGRAM TO CALCULATE THE WATER QUALITY IN A RIVER BASIN.
C     PROGRAMMED BY
C                     W WADDEL
C                     BATTELLE NORTHWEST
C                     P O BOX 999
C                     RICHLAND, WASHINGTON
C     THIS PROGRAM CALCULATES THE CONCENTRATIONS OF SIXTEEN WATER QUALITY
C     PARAMETERS IN A RIVER SYSTEM.  IT IS PART OF BNW'S EXPLORE-I CODE
C     FOR THE DYNAMIC ANALYSIS OF RIVER BASIN WATER QUALITY.  THE
C     HYDRAULIC INPUT TO THIS CODE IS GENERATED BY THE BNW HYDRAULIC
C     MODEL.  THE QUALITY INPUT IS PREPARED BY QMAINT, THE INPUT PORTION
C     OF THIS CODE
C
      COMMON/ALL/MAXCON, IDOCNT, NJ, HOURS, ICYCLE, KCON
      COMMON/AQUAL/TOCIN(50, 6), TOCCAL(2), BENIN(50, 2), BENCAL(2),
     1              BODIN(50, 6), BODCAL(2), TOXIN(50, 3), TOXCAL(2),
     2              SPRIN(50, 5), SPRCAL(2), APRIN(50, 5), APRCAL(2),
     3              REAIN(50, 5), REACAL(2), TININ(50, 3), DOXCAL(2),
     4              ALGIN(50, 17), ALGCAL(6), PHOIN(50, 3)
      COMMON/BQUAL/MODBOD, MODDOX, MODREA, MODTIN, MODPHO, MODALG, I, J,
     1              TEMPR, DEPTH, IZRCON(16)
      COMMON/ATRAN/MAXNNE, NCNTND, NSOURC, NREACH, ITIDE, DELTS, TIDCOF,
     1              NUPSTR, EVAP
      COMMON/BTRAN/C(400, 16), SOURIN(50, 16), UPSTR(50, 16), SURFAR(400),
     1              IUPSTR(50), ISOURC(50), IREACH(400), ICNTND(50),
     2              NCHAN(400, 6), NJUNC(500, 2), Q(500), U(500), HBAR(400),
     3              ALEN(500), DEP(400), VOL(400), DOCONT(50), QINBAR(400),
     4              QOUBAR(400)
C
      DIMENSION TEMP(50)
      DIMENSION Y(16), Y0(16), REATEM(3, 400)
      DIMENSION ALPHA(30),  ALPHAQ(20)
C
      EXTERNAL DE
C
C************************** ASSIGN TAPE UNITS AND REWIND TAPES  ***************
C                           UNIT NTA IS THE QUALITY INPUT DATA TAPE
C                           UNIT NTB IS THE HYDRAULIC DATA TAPE
C                           UNIT NTC IS THE QUALITY OUTPUT TAPE
C
      DATA NTA/3/, NTB/2/, NTC/7/
      REWIND NTA
      REWIND NTB
C
C************************** READ CONSTANTS FROM HYDRAULIC INPUT TAPE **********
C
      MAXCON=16.
      MAXNNE=6
      READ(NTB)(ALPHA(I), I=1, 30), NJ, NC, NQCYC, DELTS, NTCYC, NQSWRT, NCNTND,
     1        EVAP, ((NCHAN(J, K), K=1, MAXNNE), DEP(J), SURFAR(J), J=1, NJ),
     2          (ALFN(N), (NJUNC(N,K),K=1,2),N=1,NC),PERIOD,
     3          (ICNTND(I),I=1,NCNTND)
      READ(NTB)
C
C*************************** READ CONSTANTS FROM QUALITY INPUT TAPE ************
C
      READ(NTA)(ALPHAQ(I),I=1,20),ISTART,MODALG,MODBOD,MODDOX,MODTIN,
     1          MODPHO,MODREA,NREACH,NSOURC,H1,(IREACH(I),I=1,NJ),
     2          (ISOURC(I),I=1,NSOURC),NUPSTR,TIDCOF,(IUPSTR(I),I=1,
     3          NUPSTR),NTQCYC,ICONST
      READ(NTA)((RODIN(I,K),K=1,6),I=1,NREACH)
      READ(NTA)((BENIN(I,K),K=1,2),I=1,NREACH)
      READ(NTA)((TOCIN(I,K),K=1,6),I=1,NREACH)
      READ(NTA)((TOXIN(I,K),K=1,3),I=1,NREACH)
      READ(NTA)((SPRIN(I,K),K=1,5),I=1,NREACH)
      READ(NTA)((APRIN(I,K),K=1,5),I=1,NREACH)
      READ(NTA)((REAIN(I,K),K=1,5),I=1,NREACH)
      READ(NTA)((PHOIN(I,K),K=1,3),I=1,NREACH)
      READ(NTA)((TININ(I,K),K=1,3),I=1,NREACH)
      READ(NTA)((ALCIN(I,K),K=1,17),I=1,NREACH)
      READ(NTA)((C(J,K),K=1,MAXCON),J=1,NJ)
C
C*************************** INITIALIZE VARIBLES ******************************
C
      KCON=MAXCON
      DO 100 K=1,KCON
  100 IZRCON(K)=1
      DAYS=0.
      DELTH=DELTS/3600.
      DELTD=DELTH/24.
      NCYCLE=(NTQCYC-NQSWRT+1)*NQCYC
      NRCHDC=(NTCYC-NQSWRT+1)*NQCYC
      IZRCHK=1
      ICYCLE=0
      ITIDE=-1
      H1=H1+0.5
      INTER=IFIX(H1)
      IREADC=0
      IRENND=0
      HOURS=-DELTH/2.
C
C*************************** DETERMINE IF THIS IS A RESTART *******************
C                                           CASE (ISTART=1)
C                                 IF NOT SKIP TO STATEMENT 898
C
      IF (ICONST.GT.0) GO TO 898
      IF(ISTART.LE.0)  GO TO 898
C
C*************************** READ RESTART DATA CARDS **************************
C
      READ(5,897) ITCYC,IHOUR
  897 FORMAT(2I5)
```

```
      WRITE(6,899) ITCYC,IHOUR
 899  FORMAT('  TIDAL CYCLE=',I5,' HOUR=' ,I5)
      ITID=ITCYC
      IHR=IHOUR-1
      IF(IHR.LT.1) ITID =ITCYC-1
      IF(IHR.LT.1)IHR=NQCYC
      IF(ITID.LT.NUSWRT) GO TO 898
      IREWND=(ITID-NQSWRT)/(NTCYC-NQSWRT+1)
      NHDAY=ITID-IREWND*(NTCYC-NQSWRT+1)
C
C************************** POSITION TAPES AND CALCULATE PARAMETERS ***********
C                                                      FOR RESTART
C
 888  READ(NTA) NT,NQ
      READ(NTA)
      IF(NT.NE.ITID)  GO TO 888
      IF(NQ.NE.IHR)  GO TO 808
 887  READ(NTB) NT,NQ
      IF(NT.NE NHDAY) GO TO 887
      IF(NQ.NE.IHR) GO TO 887
      ICYCLE=(ITID-NQSWRT)*NQCYC+IHR
      HOURS=(  FLOAT((ITID-NQSWRT)*NQCYC+IHR)*DELTH/24.)
      DAYS=FLOAT(IFIX(HOURS))
      HOURS=(HOURS-DAYS)*24.-DELTH/2.
      IREADC=IHR+(NHDAY-NQSWRT)*NQCYC
 898  CONTINUE
C
C****************************** ADVANCE VARIBLES FOR NEXT TIME STEP *************
C
  110 HOURS=HOURS+DELTH
      IF (HOURS.LT.24.) GO TO 115
      HOURS=HOURS-24
      DAYS=DAYS+1
  115 ICYCLE=ICYCLE+1
      IREADC=IPEADC+1
      KUPSTR=1
C
C****************************** CHECK TO SEE IF PROBLEM IS COMPLETE *************
C
  120 IF (ICYCLE.GT.NCYCLE) GO TO 600
C
C****************************** READ IN TIME VARYING DATA ***********************
C
      IF (ICONST.GE.0) GO TO 125
      NQ=NQ+1
      IF (NQ.LE.NQCYC) GO TO 125
      NQ=1
      NT=NT+1
  125 CONTINUE
      IF (ICONST.LT.0) GO TO 150
      IF (ICONST.GT.0) ICONST=-1
      IF (IREADC.LE.NREADC) GO TO 130
      REWIND NTB
      IREADC=1
      IREWND=IREWND+1
      READ (NTB)
      READ (NTB)
  130 READ (NTA) NT,NQ
      READ (NTB) NT1,NQ1,(HBAR(J),VOL(J),QINBAR(J),QOUBAR(J),J=1,NJ),
     1          (Q(N),U(N),N=1,NC)
      READ(NTA) ((SOUPIN(J,K),J=1,NSOURC),K=1,MAXCON),(TEMP(I),
     1            I=1,NREACH),(DOCONT(I),I=1,NCNTND),((UPSTR(I,J),I=1,
     2           NUPSTR),J=1,16)
C
C****************************** CHECK TO INSURE THAT TAPES ARE SYNCHRONIZED *****
C
      ITEMP=NT1+IREWND*(NTCYC-NQSWRT+1)
      IF (NT.NE.ITEMP) GO TO 140
      IF (NQ.EQ.NQ1) GO TO 150
  140 WRITE (6,9000) NT,NQ,NT1,NQ1,IREWND,ICYCLE,IREADC
 9000 FORMAT (1H ,'THE QUALITY DATA TAPE AND HYDRAULIC DATA TAPE ARE NOT
     1 SYNCHRONIZED.'/1X,7I10)
C
C****************************** DETERMINE EQUILIBRIUM CONCENTRATIONS AT EACH ****
C                                    NODE FOR THIS TIME STEP
C
  150 DO 500 J=1,NJ
      IF (J.NE.IUPSTR(KUPSTR)) GO TO 155
      DO 154 KC=1,KCON
  154 C(J,KC)=UPSTR(KUPSTR,KC)
      KUPSTR=KUPSTR+1
      IF (KUPSTR.GT.NUPSTR) KUPSTR=1
      GO TO 490
  155 I=IREACH(J)
C
C****************************** CALCULATE DEPTH, TEMPERATURE, AND DO ************
C                                    CONCENTRATION FOR THIS NODE
C
      DEPTH=HBAR(J)+DEP(J)
      IF (DEPTH.GT.0.0) GO TO 158
      DO 157 KT=1,KCON
  157 C(J,KT)=0.0
      GO TO 500
  158 CONTINUE
      TEMPR=TEMP(I)
      DOXCAL(1)=14.652-0.41022*TEMPR+0.007991*TEMPR**2.0-0.000077774*
     1           TEMPR**3.0
C
C****************************** CHECK TO SEE IF DO CONCENTRATION IS TO BE *******
C                                    CONTROLLED AT THIS NODE.  IF DO IS
C                                    CONTROLLED IDOCNT = 2, OTHERWISE
C                                    IDOCNT = 1
C
      DO 160 JT=1,NCNTND
      IF (J.NE NJUNC(JT,2)) GO TO 160
      IF (DOCONT(JT).LT.0.) GO TO 165
      C(J,16)=DOCONT(JT)+DOXCAL(1)
      IDOCNT=2
      GO TO 170
  160 CONTINUE
  165 IDOCNT=1
C
C***************************** CALCULATE REAERATION COEFFICIENT FOR THIS *******
C                                      NODE AND ADJUST ALL CONSTANTS FOR
C                                      TEMPERATURE
C
  170 IF (IDOCNT EQ.2) GO TO 180
      CALL REA
  180 CALL TEMPER
C
C***************************** SET UP CONCENTRATIONS FOR SOLUTION AND **********
C                                      SOLVE EQUATIONS FOR THIS NODE
      DO 190 K=1,KCON
      Y(K)=0.
  190 Y0(K)=C(J,K)
      Y0(1)=Y0(1)/(DEPTH*.3048)
  200 CALL DIFEQ(0.,DELTD,Y0,Y,MAXCON,INTER,DE)
C
C***************************** CHECK TO SEE IF ANY CONCENTRATION WENT       ***
C                                      NEGATIVE DURING THE INTEGRATION (IZRCHK
C                                      =-1 ) IF SO THAT CONCENTRATION WILL
C                                      BE SET TO ZERO AND THE INTEGRATION
C                                      STARTED OVER.
C
      IZRCHK=1
      DO 205 K=1,KCON
      IF (Y(K).GE.0.) GO TO 205
      Y0(K)=0.
      IZRCON(K)=-1
      IZRCHK=-1
  205 CONTINUE
      IF (IZRCHK.LT.0) GO TO 200
C
C***************************** RESET CONCENTRATIONS AND GO TO NEXT NODE ********
C
      Y(1)=Y(1)*(DEPTH*.3048)
      DO 230 K=1,KCON
      IZRCON(K)=1
  230 C(J,K)=Y(K)
  490 REATEM(1,J)=REACAL(2)
      REATEM(2,J)=  SPRCAL(1)
      REATEM(3,J)=  TEMP(I)
  500 CONTINUE
C
C***************************** PRINT OUT RESULTS *******************************
C
```

```
      WRITE(NTC)  NT, NQ
      WRITE(NTC)   ((C(J,K),K=1,16),(REATEM(L,J),L=1,3),J=1,NJ)
  550 CONTINUE
C
C**************************** TRANSPORT CONCENTRATIONS AND ADD BOTH ***********
C                                       HYDRAULIC AND QUALITY SOURCES.
C                                       GO TO NEXT TIME STEP.
C
      CALL TRANSP
      GO TO 110
  600 CONTINUE
      END FILE NTC
      CALL PRINT(NQSWRT,NTQCYC,NTC,PERIOD,DELTH,NQCYC,NJ)
      CALL EXIT
      STOP
      END
      SUBROUTINE REA
C
C         THIS SUBROUTINE CALCULATES THE AVERAGE REAERATION COEFFICIENT
C         FOR A NODE.  THE COEFFICIENT FOR EACH CONNECTED CHANNEL IS
C         CALCULATED AND THEN A FLOW WEIGHTED AVERAGE IS TAKEN.  THERE
C         ARE FOUR MODELS AVAILABLE AS DESIGNATED BY MODREA
C
C              MODREA
C                1         GENERAL MODEL    (K2=A1*(VELOCITY**A2)/(DEPTH**A3)
C                2         O'CONNOR - DOBBINS  MODEL
C                3         DOBBINS MODEL
C                4         THACKSTON - KRENKEL MODEL
C
C
C
      COMMON/ALL/MAXCON,IDOCNT,NJ,HOURS,ICYCLE,KCON
      COMMON/AQUAL/TOCIN(50,6),TOCCAL(2),BENIN(50,2),BENCAL(2),
     1             BODIN(50,6),BODCAL(2),TOXIN(50,3),TOXCAL(2),
     2             SPRIN(50,5),SPRCAL(2),APRIN(50,5),APRCAL(2),
     3             REAIN(50,5),REACAL(2),TININ(50,3),DOXCAL(2),
     4             ALGIN(50,17),ALGCAL(6),PHOIN(50,3)
      COMMON/BQUAL/MODBOD,MODDOX,MODREA,MODTIN,MODPHO,MODALG,I,J,
     1             TEMP,DEPTH,IZPCON(16)
      COMMON/ATRAN/MAXNNE,NCNTND,NSOURC,NREACH,ITIDE,DELTS,TIDCOF,
     1             NUPSTR,EVAP
      COMMON/BTRAN/C(400,16),SOURIN(50,16),UPSTR(50,16),SUMTAR(400),
     1             IUPSTR(50),ISOURC(50),IREACH(400),ICNTND(50),
     2             NCHAN(400,6),NJUNC(500,2),Q(500),U(500),HBAR(400),
     3             ALEN(500),DEP(400),VOL(400),DOCONT(50),QINBAR(400),
     4             QOUBAR(400)
C
C
C****************************** INITIALIZE VARIBLES ******************************
C
      RETEM2=0.
      QTEMP=0.
C
C****************************** CHECK EACH CHANNEL CONNECTED TO NODE J **********
C
      DO 500 IT1=1,MAXNNE
      IT2=NCHAN(J,IT1)
      IF (IT2.EQ.0) GO TO 600
      IF (IT2.LT.0) GO TO 500
      IF (IT2.LE.NCNTND) GO TO 500
      IF (J.EQ.NJUNC(IT2,1)) GO TO 100
      IT3=NJUNC(IT2,1)
      GO TO 150
  100 IT3=NJUNC(IT2,2)
C
C****************************** CALCULATE PHYSICAL PROPERTIES OF CHANNEL ********
C
```

```
  150 DEPT2=ABS(HBAR(IT3)+DEP(IT3))
      DEPT1=ABS((DEPTH+DEPT2)/2. )
      VELO=ABS(U(IT2))
      FLOW=ABS(Q(IT2))
      SLOPE=ABS((HBAR(IT3)-HBAR(J))/ALEN(IT2))
      IF ((DEPT1. LE. 0. 0). OR. (SLOPE. EQ. 0. 0)) GO TO 700
C
C***************************** SELECT REAERATION MODEL *************************
C
      GO TO (10,20,30,40),MODREA
C
C***************************** GENERAL MODEL. ***********************************
C
   10 RETEM1=REAIN(I,1)*VELO**REAIN(I,2)/DEPT1**REAIN(I,3)
      GO TO 200
C
C***************************** O'CONNOR - DOBBINS MODEL ************************
C
   20 B=VELO/SQRT(DEPT1*SLOPE)
      IF (B. GE. 17. 0) GO TO 25
      RETEM1=480. *SQRT(REAIN(I,5))*SLOPE**. 25/DEPT1**7. 25
      GO TO 200
   25 RETEM1=SQRT(REAIN(I,5)*VELO)/(2. 31*DEPT1**(-1. 5))
      GO TO 200
C
C***************************** DOBBINS MODEL ***********************************
C
   30 COEF1=(1. 0+VELO**2. 0)/DEPT1*32. 2
      COEF2=0. 9+VELO/SQRT(DEPT1*32. 2)
      COEF3=9. 68+0. 054*(TEMPR -20. )
      COEF4=0. 976+0. 0137*(ABS(30. 0-TEMPR))**1. 5
      COEF5=30. 0*SLOPE*VELO/1000.
      ARGU=COEF4*COEF5**. 125/SQRT(COEF2)
      RETEM1=0. 12*COEF1*COEF3*COEF5**. 375*(COSH(ARGU)/SINH(ARGU))/
     1(COEF2**1. 5*DEPT1)
      GO TO 200
C
C***************************** THACKSTON - KRENKEL MODEL ***********************
C
   40 RETEM1=0. 000125*(1. +SQRT(VELO)/((32. 2*DEPT1)**0. 25))*
     1       SQRT(SLOPE*32. 2/DEPT1)*86400.
      GO TO 200
C
C***************************** SUM FLOWS AND FLOW WEIGHTED K2'S ****************
C
  200 RETEM2=RETEM2+RETEM1*FLOW
      QTEMP=QTEMP+FLOW
  500 CONTINUE
C
C***************************** CALCULATE FLOW WEIGHTED AVERAGE *****************
C
  600 IF (QTEMP. LE. . 0000001) GO TO 700
```

```
      REACAL(1)= RETEM2/ QTEMP
      IF (REACAL(1).LT.0.) REACAL(1)=0.
      GO TO 800
  700 REACAL(1)=0.
  800 IF (MODREA.EQ.3) REACAL(2)=REACAL(1)
      RETURN
      END
```

```
      SUBROUTINE TEMPER
C
C        THIS SUBROUTINE CALCULATES THE TEMPERATURE CORRECTION FOR
C        THE RATE CONSTANTS USED IN THE OTHER SUBPROGRAMS.  NOTE
C        THAT THE REAERATION MODEL 3 DOES NOT REQUIRE A TEMPERATURE
C        CORRECTION.
C
      COMMON/ALL/MAXCON, IDOCNT, NJ, HOURS, ICYCLE, KCON
      COMMON/AQUAL/TOCIN(50,6),TOCCAL(2),BENIN(50,2),BENCAL(2),
     1             BODIN(50,6),BODCAL(2),TOXIN(50,3),TOXCAL(2),
     2             SPRIN(50,5),SPRCAL(2),APRIN(50,5),APRCAL(2),
     3             REAIN(50,5),REACAL(2),TININ(50,3),DOXCAL(2),
     4             ALGIN(50,17),ALGCAL(6),PHOIN(50,3)
      COMMON/BQUAL/MODUAD, MODDOX, MODREA, MODTIN, MODPHO, MODALG, I, J,
     1             TEMPR, DEPTH, IZRCON(16)
C
      TEMPR1=TEMPR-20.0
      BODCAL(1)=BODIN(I,1)*BODIN(I,4)**TEMPR1
      BODCAL(2)=BODIN(I,5)*BODIN(I,6)**TEMPR1
      TOCCAL(1)=TOCIN(I,1)*TOCIN(I,6)**TEMPR1
      BENCAL(1)=BENIN(I,1)*BENIN(I,2)**TEMPR1
      TOXCAL(1)=TOXIN(I,1)*TOXIN(I,3)**TEMPR1
      IF (MODREA.EQ.3) RETURN
      REACAL(2)=REACAL(1)*REAIN(I,4)**TEMPR1
      RETURN
      END
      SUBROUTINE TRANSP
C
C     THIS SUBROUTINE CALCULATES THE CHANGE IN CONCENTRATION AT EACH NODE
C     DUE TO TRANSPORT FROM ADJACENT NODES AND ADDITION OF HYDRAULIC AND
C     QUALITY PARAMETER SOURCES
C
C        THE FOLLOWING NOTATION IS USED
C
C              DCDT(J,K)       STORES THE CHANGE IN CONCENTRATION AT NODE J
C              ADDC(J,K)       STORES THE MASS FOR INPUT TO NODE IN TWO CASES
C                                 1. A NODE DOWNSTREAM OF CONTROLLED NODE J
C                                 2. A TIDAL NODE J
C
C              ADDQ(J)         STORES THE FLOWS INTO NODE J
C              TIDMAS(K)       INTEGRATES THE MASS OF PARAMETER K ON THE EBB
C                                  TIDE
C              SUMQ            SUMS FLOWS INTO NODE J
C
C
C
      COMMON/ALL/MAXCON, IDOCNT, NJ, HOURS, ICYCLE, KCON
      COMMON/ATRAN/MAXNNE, NCNTND, NSOURC, NREACH, ITIDE, DELTS, TIDCOF,
     1             NUPSTR, EVAP
      COMMON/BTRAN/C(400,16), SOURIN(50,16), UPSTR(50,16), SURFAR(400),
     1             IUPSTR(50), ISOURC(50), IREACH(400), ICNTND(50),
     2             NCHAN(400,6), NJUNC(500,2), Q(500), U(500), HBAR(400),
     3             ALEN(500), DEP(400), VOL(400), DOCONT(50), QINBAR(400),
     4             QOUBAR(400)
      COMMON/AQUAL/TOCIN(50,6), TOCCAL(2), BENIN(50,2), BENCAL(2),
     1             BODIN(50,6), BODCAL(2), TOXIN(50,3), TOXCAL(2),
     2             SPRIN(50,5), SPRCAL(2), AMRIN(50,5), AMRCAL(2),
     3             REAIN(50,5), REACAL(2), TININ(50,3), DOXCAL(2),
     4             ALGIN(50,17), ALGCAL(6), PHOIN(50,3)
C
      DIMENSION DCDT(400,16)
      DIMENSION ADDC(50,16),  ADDQ(400),  ADDCON(16)
      DIMENSION TIDMAS(16)
C
C
C
C***************************** ZERO OUT THE ARRAY ADDC(J,KC) *******************
C
      ZERERR=.00000000001
      DO 20 J=1,NCNTND
      DO 20 KC=3,KCON
   20 ADDC(J,KC)=0.
C
C***************************** BEGINNING OF DO LOOP TO CALCULATE  **************
C                               THE CHANGE IN CONCENTRATION OF A
C                               QUALITY PARAMETER AT NODE J
C
```

```
      DO 500 J=1,NJ
C
C****************************** INITIALIZE VARIBLES FOR NODE J *****************
C
      SUMQ=0.
      ADDQ(J)-0.
      NODE=1
      DO 10 KC=3,KCON
   10 DCDT(J,KC)=0.
C
C****************************** CHECK EACH CHANNEL CONNECTED TO NODE J  *********
C                               1. IF  N .LT. 0  CHANNEL IS DRY SO DO NOT
C                                      CALCULATE ANY CHANGE DUE TO THAT
C                                      CHANNEL
C                               2. IF  N .EQ. 0  ALL CHANNELS INTO THIS
C                                      NODE HAVE BEEN CHECKD SO STOP LOOP
C                               3. IF  N .LE. NCNTND THEN THIS CHANNEL IS
C                                      CONNECTED DOWNSTREAM OF A CONTROLLED
C                                      NODE.  SO SET NODE=-1 AND DO NOT
C                                      CALCULATE ANY CHANGE DUE TO THIS
C                                      CHANNEL
C                               4. IF FLOW IS OUT OF NODE DO NOT CALCULATE
C                                      ANY CHANGE DO TO THIS CHANNEL
      DO 300 K=1,MAXNNE
      N=NCHAN(J,K)
      IF (N.EQ.0) GO TO 305
      IF (N.GT.NCNTND) GO TO 100
      NODE=-1
      GO TO 300
  100 JL=NJUNC(N,1)
      JH=NJUNC(N,2)
      IF((J.EQ.JL).AND.(Q(N).GE.0.)) GO TO 300
      IF((J.EQ.JH).AND.(Q(N).LE.0.)) GO TO 300
      IF ((ABS(U(N)*DELTS)).GT.ALEN(N)) U(N)=SIGN(ALEN(N)/DELTS,U(N))
C
C****************************** SUM FLOWS AND CHANGES IN CONCENTRATIONS *********
C
      SUMQ=SUMQ+ABS(Q(N))
      DO 250 KC=3,KCON
  250 DCDT(J,KC)=DCDT(J,KC)+ABS(Q(N))*(U(N)*(C(JL,KC)-C(JH,KC))/ALEN(N))
  300 CONTINUE
C
C****************************** IF NODE .GT. 0 THEN WE KNOW THAT NODE J IS ******
C                                  NEITHER A CONTROLLED NODE NOR BELOW A
C                                  CONTROLLED NODE.  HENCE SKIP TO 450.
C
C                               IF NODE .LT. 0 THEN J IS EITHER A CONTROLLED
C                                  NODE OR BELOW A CONTROLLED NODE.
C
C                               IF  J .GT. NCNTND  THEN J MUST BE BELOW A
                                   CONTROLLED NODE SO GO TO 400
```

```
C                                      IF  ICNTND(J) .NE. 2  THEN J IS NOT A TIDALLY
C                                         CONTROLLED NODE SO GO TO 450
C
C
  305 IF (NODE.GT.0) GO TO 450
      IF (J.GT.NCNTND) GO TO 400
      IF (ICNTND(J).NE.2) GO TO 450
C
C
C***************************** AT THIS POINT WE KNOW WE HAVE A TIDALLY  ********
C                                 CONTROLLED NODE.  WE MUST NOW DETERMINE
C                                 IF WE ARE ON THE EBB OR FLOOD TIDE.
C                                 Q(N) .GT.  0 IMPLIES A FLOOD TIDE, AND
C                                 Q(N) .LT.  0 IMPLIES AN EBB TIDE.  IF WE
C                                 ARE ON AN EBB TIDE WE MUST DETERMINE IF
C                                 THIS IS THE FIRST EBB IN THE CYCLE SO WE
C                                 CAN ZERO OUT THE MASS INTEGRAL.
C
C
      N=J
      FLOW= ABS(Q(N))
      IF (ITIDE.GT.0) GO TO 320
      IF (Q(N).GT.0) GO TO 360
C
C*************************** FIRST EBB TIDE IN CYCLE  *************************
C
      ITIDE =1
      DO 310 KC=3,KCON
  310 TIDMAS(KC)=0.
      OUTFLO=0.
  320 IF (Q(N).GT.0) GO TO 360
C
C**************************** EBB TIDE SO SUM MASS AND FLOW GOING OUT *********
C
      DO 330 KC=3,KCON
  330 TIDMAS(KC)=TIDMAS(KC)+FLOW*C(J,KC)*DELTS
      OUTFLO=OUTFLO+FLOW*DELTS
      GO TO 450
C
C**************************** FLOOD TIDE SO CALCULATE ADDITIONAL **************
C                                 CONCENTRATION AND FLOW
C
C
  360 ITIDE=-1
      IF (OUTFLO.LT.ZERERR) GO TO 450
      DO 370 KC=3,KCON
  370 ADDC(J,KC)=TIDMAS(KC)*TIDCOF*FLOW/OUTFLO
      ADDQ(J)=FLOW
      GO TO 450
C
C**************************** AT THIS POINT WE KNOW WE ARE AT A NODE  BELOW ***
C                                 A CONTROLLED NODE.  SO FIND MASS ADDED
C                                 FROM CONTROLLED NODE AND SUM FLOW.
C
C
```

```
  400 DO 420 K=1,MAXNNE
      N=NCHAN(J,K)
      IF (N.EQ.0) GO TO 450
      IF (N.LT.0) GO TO 420
      IF (N.GT.NCNTND) GO TO 420
      FLOW=ABS(Q(N))
      ADDQ(J)=ADDQ(J)+FLOW
      DO 410 KC=3,KCON
  410 ADDC(N,KC)=C(N,KC)*FLOW
  420 CONTINUE
C
C**************************** FLOW WEIGHT CHANGES IN CONCENTRATION  ***********
C
  450 IF (SUMQ.LT.ZERERR) GO TO 500
  455 DO 460 KC=3,KCON
  460 DCDT(J,KC)=DCDT(J,KC)*DELTS/SUMQ
  500 CONTINUE
C
C**************************** UPDATE  CONCENTRATIONS ***************************
C                                   DUE TO TRANSPORT
C
      DO 285 J=1,NJ
      IF(NCHAN(J,1).EQ.0) GO TO 285
      DO 284 KC=3,KCON
  283 C(J,KC)=(C(J,KC)+DCDT(J,KC))
  284 CONTINUE
C
C**************************** SET DO CONCENTRATION BELOW *********************
C                                   CONTROLLED NODES
C
      DO 600 IT=1,NCNTND
      IF (J.NE.NJUNC(IT,2)) GO TO 600
      IF (DOCONT(IT).LT.0.) GO TO 600
      I=IREACH(IT)
      C(J,16)=DOCONT(IT)*DOXCAL(1)
  600 CONTINUE
C
C****************************  CHECK DEPLETION   ******************************
C
      DO 720 KC=3,KCON
      IF(C(J,KC).LT.0.) C(J,KC)=0.
  720 CONTINUE
  285 CONTINUE
C
C**************************** START OF LOOP TO UPDATE CONCENTRATIONS  *********
C                                   DUE TO QUALITY AND HYDRAULIC SOURCES
C
      KUPSTR=1
      DO 1000 J=1,NJ
C
C**************************** IF J IS AN UPSTREAM NODE SKIP CALCULATIONS ******
C
```

```
      IF (J.NE.IUPSTR(KUPSTR)) GO TO 770
      KUPSTR=KUPSTR+1
      IF (KUPSTR.GT.NUPSTR) KUPSTR=1
      GO TO 1000
  770 CONTINUE
      DO 780 KC=3,KCON
  780 ADDCON(KC)=0.
C
C****************************** IF J IS A TIDALY CONTROLLED NODE ACCUMULATE *****
C                                      MASS IN ADDCON ARRAY
C
      IF (J.GT.NCNTND) GO TO 800
      IF (ICNTND(J).NE.2) GO TO 990
      DO 790 KC=3,KCON
  790 ADDCON(KC)=ADDC(J,KC)
      GO TO 990
C
C****************************** IF J IS DOWNSTREAM FROM A CONTROLLED NODE  ******
C                                      ADD MASS FROM CONTROLLED NODE
C
  800 DO 850 K=1,MAXNNE
      N=NCHAN(J,K)
      IF (N.EQ.0) GO TO 990
      IF (N.LT.0) GO TO 850
      IF (N.GT.NCNTND) GO TO 850
      DO 840 KC=3,KCON
  840 ADDCON(KC)=ADDCON(KC)+ADDC(N,KC)
  850 CONTINUE
C
C****************************** IF J IS A SOURCE NODE ADD MASS DUE TO  **********
C                                    QUALITY SOURCES
C
  990 DO 992 K=1,NSOURC
      IF (J.NE.ISOURC(K)) GO TO 992
      DO 991 KC=3,KCON
  991 ADDCON(KC)=ADDCUN(KC)+SOURIN(K,KC)*0.18544
      GO TO 993
  992 CONTINUE
  993 CONTINUE
C
C****************************** ADD MASS AND DILUTE CONCENTRATION ***************
C
      ADDQ(J)=ADDQ(J)+QINBAR(J)
      IF (VOL(J)+ADDQ(J)*DELTS-EVAP*SURFAR(J)*DELTS) 996,996,998
  996 DO 997 KC=3,KCON
  997 C(J,KC)=0.
      GO TO 1000
  998 DO 999 KC=3,KCON
  999 C(J,KC)=(C(J,KC)*VOL(J)+ADDCON(KC)*DELTS)/(VOL(J)+ADDQ(J)*DELTS
     1       -EVAP*SURFAR(J)*DELTS)
 1000 CONTINUE
      RETURN

      END
      SUBROUTINE BOD(RLC,RLN,DLCDT,DLNDT)
C
C         THIS SUBROUTINE CALCULATES THE RATE OF CHANGE OF THE BOD BASED
C         ON A FIRST ORDER REACTION.  TWO MODELS ARE POSSIBLE DEPENDING
C         ON THE VALUE OF MODBOD
C
C                   MODBOD
C                     1         BOTH CARBONACEOUS AND NITROGENOUS
C                                      BOD ARE CONSIDERED
C                     2         ONLY TOTAL BOD IS CONSIDERED
C
C         THE FOLLOWING NOMENCLATURE IS USED
C
C                   BODIN(I,2).....SEDIMENTATION CONSTANT, K3
C                   BODIN(I,3).....SCOUR CONSTANT, PC
C                   BODCAL(1)......DEOXYGENATION CONSTANT FOR CARBONACEOUS K1
C                   BODCAL(2)......DEOXYGENATION CONSTANT FOR NITROGENOUS K1
C                   RLC ..........CARBONACEOUS BOD CONCENTRATION
C                   RLN ..........NITROGENOUS BOD CONCENTRATION
C                   DLCDT ........CARBONACEOUS BOD DERIVATIVE
C                   DLNDT ........NITROGENOUS  BOD DERIVATIVE
C
      COMMON/ALL/MAXCON,IDOCNT,NJ,HOURS,ICYCLE,KCON
      COMMON/AQUAL/TOCIN(50,6),TOCCAL(2),BENIN(50,2),BENCAL(2),
     1              BODIN(50,6),BODCAL(2),TOXIN(50,3),TOXCAL(2),
     2              SPRIN(50,5),SPRCAL(2),APRIN(50,5),APPCAL(2),
     3              REAIN(50,5),REACAL(2),TININ(50,3),DOXCAL(2),
     4              ALGIN(50,17),ALGCAL(6),PHOIN(50,3)
      COMMON/BQUAL/MODBOD,MODDOX,MODREA,MODTIN,MODPHO,MODALG,I,J,
     1              TEMPR,DEPTH,IZRCON(16)
C
C
C***************************** CHECK BOD MODEL *********************************
C
      GO TO (100,200),MODBOD
C
C***************************** BOD MODEL WITH BOTH CARBONACEOUS AND  ***********
C                                    NITROGENOUS BOD HAS BEEN CHOSEN.
C                                    DETERMINE IF DO CONCENTRATION IS
C                                    ZERO
C
  100 IF (IZRCON(16))130,130,110
C
C***************************** DO CONCENTRATION IS NOT ZERO *******************
C
  110 DLCDT= -(BODCAL(1)+BODIN(I,2))*RLC
      DLNDT= -(BODCAL(2))*RLN
C
C***************************** CHECK BENTHIC BOD CONCENTRATION TO  ************
C                                    DETERMINE IF SCOUR IS POSSIBLE
      IF (IZRCON(1))500,500,115
  115 DLCDT=DLCDT + BODIN(I,3)
      GO TO 500
C
C***************************** DO CONCENTRATION IS ZERO ***********************
C
  130 DLCDT=-(BODIN(I,2)+DOXCAL(2)*BODCAL(1))*RLC
      DLNDT=-DOXCAL(2)*KLN
C
C***************************** CHECK BENTHIC BOD CONCENTRATION TO  *************
C                                       DETERMINE IF SCOUR IS POSSIBLE
C
      IF (IZRCON(1)) 500,500,135
  135 DLCDT=DLCDT+ BODIN(I,3)
      GO TO 500
C
C*****************************  BOD MODEL FOR TOTAL BOD HAS BEEN  **************
C                                       CHOSEN. DETERMINE IF DO
C                                       CONCENTRATION IS ZERO.
C
  200 IF (IZRCON(16)) 230,230,210
C
C*****************************  DO CONCENTRATION IS NOT ZERO ******************
C
  210 DLCDT=-(BODCAL(1)+BODIN(I,2))*RLC
      DLNDT=0.
C
C***************************** CHECK BENTHIC BOD CONCENTRATION TO  *************
C                                       DETERMINE IF SCOUR IS POSSIBLE
C
      IF (IZRCON(1)) 500,500,215
  215 DLCDT=DLCDT + BODIN(I,3)
      GO TO 500
C
C***************************** DO CONCENTRATION IS ZERO ***********************
C
  230 DLCDT= -(BODIN(I,2)+DOXCAL(2)*BODCAL(1))*RLC
      DLNDT=0.
C
C***************************** CHECK BENTHIC BOD CONCENTRATION TO  *************
C                                       DETERMINE IF SCOUR IS POSSIBLE
C
      IF (IZRCON(1)) 500,500,235
  235 DLCDT=DLCDT + BODIN(I,3)
C
C***************************** CHECK FOR ZERO CONCENTRATIONS *******************
C
  500 IF (IZRCON(5).LT.0) DLCDT=0.
      IF (IZRCON(6).LT.0) DLNDT=0.
C
      RETURN
      END
      SUBROUTINE DIFEQ(XE.X,Y,YF,NN,I,DE)
C
C        THIS SUBROUTINE SOLVES A SIMULTANEOUS SET OF FIRST
C        ORDER EQUATIONS USING A FOURTH ORDER RUNGE-KUTTA
C        METHOD.
C
      DIMENSION Y(16),YI(16),AM1(16),AM2(16),AM3(16),AM4(16)
      DIMENSION YF(16)
C
C****************************** INITIALIZE VARIABLES *****************************
C
      FI=I
      XF=X
      H=ABS((XE-XF)/FI)
      N=NN
      DO 10J=1,N
   10 YF(J)=Y(J)
C
C****************************** CALCULATE DERIVATIVES ****************************
C
      DO 50 J=1,I
      CALL DE(XF,YF,AM1)
      XF=XF+H/2.0
      DO 20 K=1,N
   20 YI(K)=YF(K)+AM1(K)*H/2.0
      CALL DE(XF,YI,AM2)
      DO 30 K=1,N
   30 YI(K)=YF(K)+AM2(K)*H/2.0
      CALL DE(XF,YI,AM3)
      XF=XF+H/2.0
      DO 40 K=1,N
   40 YI(K)=YF(K)+AM3(K)*H
      CALL DE(XF,YI,AM4)
C
C****************************** CALCULATE NEW VALUE ******************************
C
      DO 50 K=1,N
   50 YF(K)=H/6.0*(AM1(K)+AM4(K)+2.0*(AM2(K)+AM3(K)))+YF(K)
C
      RETURN
      END
      SUBROUTINE DE (T,Y,F)
C
C         THIS SUBROUTINE EVALUATES THE DERIVATIVES FOR THE DIFEQ  ROUTINE
C
C         THE FOLLOWING NOTATION IS USED
C
C             Y(I)............VALUE OF ITH CONCENTRATION
C             F(I,1)..........VALUE OF DERIVATIVE FOR ITH CONCENTRATION
C
      COMMON/ALL/MAXCON, IDOCNT, NJ, HOURS, ICYCLE, KCON
      COMMON/EQUAL/TOCIN(50,6),TOCCAL(2),BENIN(50,2),BENCAL(2),
     1             BODIN(50,6),BODCAL(2),TOXIN(50,3),TOXCAL(2),
     2             SPRIN(50,5),SPRCAL(2),APRIN(50,5),APRCAL(2),
     3             REAIN(50,5),REACAL(2),TININ(50,3),DOXCAL(2),
     4             ALGIN(50,17),ALGCAL(6),PHOIN(50,3)
      COMMON/DQUAL/MODMOD,MODDOX,MODREA,MODTIN,MODPHO,MODALG,I,J,
     1             TEMPR,DEPTH,IZRCON(16)
C
      DIMENSION Y(16),F(16,1)
C
C
C**************************** CALCULATE NITROGEN AND PHOSPHORUS CONCEN- *******
C                                      TRATIONS FOR USE IN ALG ROUTINE
C
      ALGCAL(5)=Y(9)+Y(11)
      ALGCAL(6)=Y(3)
C
C**************************** CALL SUBROUTINES FOR EVALUATION OF       *********
C                                      DERIVATIVES. NOTF THAT ALG MUST BE
C                                      CALLED BEFORE  PHO AND TIN AND SPR
C                                      AND APR MUST BF CALLED BEFORE DOX
C
      CALL ALG(Y(14),Y(15),F(14,1),F(15,1))
      CALL PHO(Y(3),Y(2),Y(4),Y(14),Y(15),F(3,1),F(2,1),F(4,1))
      CALL TIN(Y(9),Y(10),Y(11),Y(12),Y(14),Y(15),F(9,1),F(10,1), F(11,1
     1        ),F(12,1))
      CALL SPR(Y(14))
      CALL APR
      CALL DOX(Y(16),Y(5),Y(6),Y(1),F(16,1))
      CALL BOD(Y(5),Y(6),F(5,1),F(6,1))
      CALL BEN(Y(1),Y(5),F(1,1))
      CALL TOC(Y(8),Y(7),Y(5),F(8,1),F(7,1))
      CALL TOX(Y(13),F(13,1))
C
      RETURN
      END
```

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```
      SUBROUTINE PRINT(NOSWRT,NOTCYC,IUNIT,PERIOD,DELTO,NOCYC,NJ)
C
C         THIS SUBROUTINE PRINTS THE OUTPUT FOR THE QUALITY PROGRAM
C
C
      DIMENSION C(400,19)
      DIMENSION NJW(20),TITLE(20)
C
      REAL ICYC
C
C****************************** READ CARD INPUT ************************************
C
 200  READ(5,1,END=201) TITLE
 1    FORMAT(20A4)
      GO TO 202
 201  RETURN
 202  CONTINUE
      READ(5,2) ID1,IHR1,IDL,IHRL
 2    FORMAT (4I10 )
      READ(5,82) IPCH,IALL
 82   FORMAT(2I5)
C
C****************************** INITIALIZE VARIABLES ******************************
C
      IF(IHR1.LT.1)  IHR1=1
      IF(IHR1.GT.24)  IHR1=24
      IF(IHRL.LT.1)  IHRL=1
      IF(IHRL.GT.24)  IHRL=24
      IF (ID1.LT.1) ID1=1
      IF(ID1.LT.NOSWRT)  ID1=NOSWRT
      IF(ID1.GT.IDL)  IDL=ID1
      IF((ID1.EQ.IDL).AND.(IHR1.GT.IHRL))  IHRL=IHR1
      H1=FLOAT(IHR1+(ID1-1)*24+NOSWRT*NOCYC)
      HL=FLOAT(IHRL+(IDL-1)*24+NOSWRT*NOCYC)
      IDAY1=IFIX(H1/(FLOAT(NOCYC)*DELTO))
      IDAYL=IFIX(HL/(FLOAT(NOCYC)*DELTO))
      NS=IFIX( H1-FLOAT(IDAY1 *NOCYC) *DELTO)
      NL=IFIX( HL-FLOAT(IDAYL *NOCYC) *DELTO+0.5*DELTO)
      IF(NS.LE.0)  IDAY1=IDAY1-1
      IF(NS.LE.0)  NS=NOCYC
      IF (NL.LE.0) IDAYL=IDAYL-1
      IF (NL.LE.0) NL=24
      IF (IDAY1.LT.NOSWRT)  NS=1
      IF(IDAY1.LT.NOSWRT) IDAY1=NOSWRT
      IF (IDAY1.GT.NOTCYC) IDAY1=NOTCYC
      IF(IDAYL.GT.NOTCYC) IDAYL=NOTCYC
      IDAYL=MAX0(IDAYL,IDAY1)
      IF((IDAYL.EQ.IDAY1).AND.(NS.GT.NL))   NL=NS
      WRITE(6,3)  TITLE
 3    FORMAT(1H1,20A4, 6X,20HBATTELLE NORTHWEST,
     121H RICHLAND, WASHINGTON /87X,20HEXPLORE-1 CODE QUALITY MODEL )
```

```
C
C****************************** SEARCH DATA TAPE FOR THE DESIRED ****************
C                                      DAY AND HOUR
C
      REWIND IUNIT
 5    READ(IUNIT) NTP,NOP
      IF(NTP.GE.IDAY1) GO TO 6
      READ(IUNIT)
      GO TO 5
 6    CONTINUE
      IF (NS.EQ.1) GO TO 71
  81 READ(IUNIT)
      READ (IUNIT) NTP,NOP
      IF (NOP.NE.NS)  GO TO 81
  71 CONTINUE
      IF(IALL.NE.1) GO TO 100
C
C****************************** PRINT INFORMATION FOR ALL THE NODES *************
C
      WRITE(6,4) ID1,IHR1,IDL,IHRL
 4    FORMAT( ' YOU HAVE REQUESTED THAT ALL NODES BE PRINTED STARTING WI
     1TH DAY',I5,' HOUR',I5,' THROUGH DAY',I5,' HOUR',I5/)
      DO 7 ND=IDAY1,IDAYL
      IDAY=IDAY1+(ND-IDAY1)
      M1=1
      M2=NOCYC
      IF(ND.EQ.IDAY1)  M1=NS
      IF(ND.EQ.IDAYL)  M2=NL
      DO 7 NQ=M1,M2
      HOUR=(FLOAT(NQ-1)+0.5)*DELTQ
 8    FORMAT(20X,' DAY',I5, '  HOUR',F6.2,
     120X,'TIDAL CYCLE',I5,' QUALITY CYCLE',I5/
     1' NODE',5X, 'TEMP.( C )',4X,10H   BEN BOD,10H  SED PHOS,10H  SOL P
     2HOS,10H  ORG PHOS,10H   CAR BOD,10H   NIT BOD,10H    REF OC,10H
     3    TOC,10H       NH3,10H       NO2/1X,124(1H*)/
     4[illegible],10H        NO3,10H      ORG N,10H     TOXIC,10H      PHYTO,
     510H        ZOO,25X,10H         DO,10H       REA,10H        P-R,/
     625X,50(1H*),25X,30(1H*) )
      READ(IUNIT) ((C(J,KC),KC=1,19),J=1,NJ)
      IF((ND.NE.IDAYL).OR.(NQ.NE.NOCYC))  READ(IUNIT)
      HRS=FLOAT(NOCYC*(IDAY-NOSWRT)+NQ)*DELTQ
      IDD=IFIX(HRS/24.0)+1
      ICYC=HRS-FLOAT(IDD-1)*24.-0.5*DELTQ
      IF (ICYC.LT.0) IDD=IDD-1
      IF (ICYC.LT.0) ICYC=ICYC+24
      DO 11 J=1,NJ
      IHEAD=J-1
      IHEAD=MOD(IHEAD,20)
      IF(IHEAD.NE.0) GO TO 335
      WRITE(6,3)  TITLE
      WRITE(6,8) IDD,ICYC,IDAY,NQ
 335  CONTINUE
```

```
      WRITE(6,9) J,C(J,19),(C(J,KC),KC=1,18)
      IF(IPCH.EQ.1)  PUNCH 500,(C(J,KC),KC=1,16)
500   FORMAT(8(1PE10.4))
11    CONTINUE
9     FORMAT(I5,5X,F10.2,5X,10(1PE10.3)/25X,5(1PE10.3),25X,3(1PE10.3))
7     CONTINUE
      GO TO 200
C
C****************************** PRINT ONLY THE INFORMATION FOR ******************
C                                       THE NODES REQUESTED
C
 100  READ(5,101) NJP
 101  FORMAT(I10)
      NJP-MIN0(20,MAX0(NJP,1))
      READ(5,102) (NJW(I),I=1,NJP)
 102  FORMAT(20I4)
      WRITE(6,103) ID1,IHR1,IDL,IHRL,NJP,(NJW(I),I=1,NJP)
 103  FORMAT(' YOU REQUESTED TO PRINT THE CONCENTRATIONS FROM DAY',I5,'
     1HOUR',I5,'  THROUGH DAY',I5,' HOUR',I5,'.'
     2/1X,I5,' NODES WILL BE PRINTED.  THEY ARE  '/20I5//)
      DO 107 ND=IDAY1,IDAYL
      IDAY=IDAY1+(ND-IDAY1)
      M1=1
      M2=NQCYC
      IF(ND.EQ.IDAY1)  M1=NS
      IF(ND.EQ.IDAYL)  M2=NL
      DO 107 NQ=M1,M2
      HRS=FLOAT(NQCYC*(IDAY-NQSWRT)+NQ)*DELTQ
      IDD=IFIX(HRS/24.0)+1
      ICYC=HRS-FLOAT(IDD-1)*24.-0.5*DELTQ
      IF (ICYC.LT.0) IDD=IDD-1
      IF (ICYC.LT.0) ICYC=ICYC+24
      HOUR=(FLOAT(NQ-1)+0.5)*DELTQ
      WRITE(6,3)  TITLE
      WRITE(6,8) IDD,ICYC,IDAY,NQ
      READ(IUNIT) ((C(J,KC),KC=1,19),J=1,NJ)
      IF((ND.NE.IDAYL).OR.(NQ.NE.NQCYC))  READ(IUNIT)
      DO 107 INDE=1,NJP
      NODE=NJW(INDE)
      WRITE(6,9) NODE,C(NODE,19),(C(NODE,KC),KC=1,18)
      J=NODE
      IF(IPCH.EQ.1)  PUNCH 500,(C(J,KC),KC=1,16)
107   CONTINUE
      GO TO 200
      END
      SUBROUTINE  ALG(P,Z,DPDT,DZDT)
C
C         THIS SUBROUTINE CALCULATES THE RATE OF CHANGE OF PHYTO-
C         PLANKTON AND ZOOPLANKTON BASED ON GROWTH AND DEATH RATES
C         PROPOSED BY DITORO, ET. AL., 1970.  TWO MODELS ARE AVAILABLE
C
C              MODALG
C                1       ALGAE CALCULATION PERFORMED
C                2       ALGAE CALCULATION NOT PERFORMED
C
C         THE FOLLOWING NOMENCLATURE IS USED
C
C              ALGCAL(1) .....PHYTO GROWTH RATE
C              ALGCAL(2) .....PHYTO DEATH RATE
C              ALGCAL(3) .....ZOO GROWTH RATE
C              ALGCAL(4) .....ZOO DEATH RATE
C              ALGCAL(5) .....EFFECTIVE NITROGEN CONCENTRATION
C              ALGCAL(6) .....EFFECTIVE PHOSPHORUS CONCENTRATION
C              P .............PHYTOPLANKTON CONCENTRATION
C              Z .............ZOOPLANKTON CONCENTRATION
C
C
C
      COMMON/ALL/MAXCON,IDOCNT,NJ,HOURS,ICYCLE,KCON
      COMMON/AQUAL/TOCIN(50,6),TOCCAL(2),BENIN(50,2),BENCAL(2),
     1             BODIN(50,6),BODCAL(2),TOXIN(50,3),TOXCAL(2),
     2             SPRIN(50,5),SPRCAL(2),APRIN(50,5),APRCAL(2),
     3             REAIN(50,5),REACAL(2),TININ(50,3),DOXCAL(2),
     4             ALGIN(50,17),ALGCAL(6),PHOIN(50,3)
      COMMON/BQUAL/MODBOD,MODDOX,MODREA,MODTIN,MODPHO,MODALG,I,J,
     1             TEMPR,DEPTH,IZRCON(16)
C
C
C**************************** SELECT ALGAE MODEL ******************************
C
      GO TO (100,200),MODALG
C
C**************************** CALCULATE PHYTOPLANKTON GROWTH RATE *************
C
  100 DTEMP=DEPTH*0.3048
      COEF1=ALGIN(I,1)*TEMPR*2.718*ALGIN(I,2)/(ALGIN(I,3)*DTEMP)
      COEF2=EXP(-ALGIN(I,4)/ALGIN(I,5)*EXP(-ALGIN(I,3)*DTEMP))
     1      -EXP(-ALGIN(I,4)/ALGIN(I,5))
      COEF3= ALGCAL(5)/(ALGIN(I,6)+ALGCAL(5))*ALGCAL(6)/(ALGIN(I,7)+
     1        ALGCAL(6))
      ALGCAL(1)= COEF1*COEF2*COEF3
C
C**************************** CALCULATE PHYTOPLANKTON DEATH RATE **************
C
      ALGCAL(2)= ALGIN(I,8)*TEMPR +ALGIN(I,9)*Z
C
C**************************** CALCULATE ZOOPLANKTON GROWTH RATE ***************
```

```
C
      ALGCAL(3)= ALGIN(I,10)*ALGIN(I,9)*ALGIN(I,11)*P/(P+ALGIN(I,11))
C
C**************************** CALCULATE ZOOPLANKTON DEATH RATE ***************
C
      ALGCAL(4)= ALGIN(I,16)*TEMPR +ALGIN(I,17)
C
C**************************** CALCULATE DERIVATIVES **************************
C
      DPDT= (ALGCAL(1)-ALGCAL(2))*P
      DZDT= (ALGCAL(3)-ALGCAL(4))*Z
      GO TO 300
C
C**************************** ZERO MODEL *************************************
C
  200 DPDT=0.
      DZDT=0.
C
C**************************** CHECK FOR ZERO CONCENTRATION *******************
C
  300 IF (IZRCON(14).LT.0) DPDT=0.
      IF (IZRCON(15).LT.0) DZDT=0.
C
      RETURN
      END
      SUBROUTINE DOX(DO,RLC,RLN,RLD,DDODT)
C
C         THIS SUBROUTINE CALCULATES THE RATE OF CHANGE OF THE DO
C
      COMMON/ALL/MAXCON,IDOCNT,NJ,HOURS,ICYCLE,KCON
      COMMON/AQUAL/TOCIN(50,6),TOCCAL(2),BENIN(50,2),BENCAL(2),
     1              BODIN(50,6),BODCAL(2),TOXIN(50,3),TOXCAL(2),
     2              SPRIN(50,5),SPRCAL(2),APRIN(50,5),APRCAL(2),
     3              REAIN(50,5),REACAL(2),TININ(50,3),DOXCAL(2),
     4              ALGIN(50,17),ALGCAL(6),PHOIN(50,3)
      COMMON/BQUAL/MODBOD,MODDOX,MODREA,MODTIN,MODPHO,MODALG,I,J,
     1              TEMPR,DEPTH,IZRCON(16)
C
C****************************** CHECK FOR CONTROLLED DO NODE  ******************
C
      GO TO (50,300),IDOCNT
C
C******************************* CHECK FOR ZERO DO CONCENTRATION ****************
C
   50 IF (IZRCON(16)) 200,200,100
C
C****************************** DO CONCENTRATION IS NOT ZERO ******************
C
  100 DDODT= -BODCAL(1)*RLC -BODCAL(2)*RLN -BENCAL(1)*RLD +REACAL(2)
     1         *(DOXCAL(1)-DO) +SPRCAL(1) +APRCAL(1)
      GO TO 400
C
C******** ******************** DO CONCENTRATION IS ZERO **********************
C
  200 DDODT=0.
      IF (BODCAL(1)*RLC+BODCAL(2)*RLN+BENCAL(1)*RLD) 230,230,205
  205 IF (SPRCAL(1)+APRCAL(1))  220,220,210
  210 DOXCAL(2)=(REACAL(2)*(DOXCAL(1)-DO) + SPRCAL(1)+APRCAL(1))/
     1          (BODCAL(1)*RLC+BODCAL(2)*RLN+BENCAL(1)*RLD)
      GO TO 400
C
  220 DOXCAL(2)=REACAL(2)*(DOXCAL(1)-DO)/(BODCAL(1)*RLC+BODCAL(2)*RLN
     1          +BENCAL(1)*RLD)
      GO TO 400
C
  230 DOXCAL(2)=0.0
      GO TO 400
C
C******************************* DO IS CONTROLLED AT THIS NODE ******************
C
  300 DDODT=0.
C
  400 RETURN
      END
      SUBROUTINE BEN(RLD,RLC,DLDDT)
C
C         THIS SUBROUTINE CALCULATES THE RATE OF CHANGE OF THE BENTHIC
C         BOD BASED ON   FIRST ORDER DEOXYGENATION WITH BOTH SCOUR AND
C         SEDIMENTATION TERMS
C
C         THE FOLLOWING NOMENCLATURE IS USED
C
C
C                    BENCAL(1)......DEOXYGENATION COEFFICIENT K4
C
C
      COMMON/ALL/MAXCON,IDOCNT,NJ,HOURS,ICYCLF,KCON
      COMMON/AQUAL/TOCIN(50,6),TOCCAL(2),BENIN(50,2),BENCAL(2),
     1             BODIN(50,6),BODCAL(2),TOXIN(50,3),TOXCAL(2),
     2             SPRIN(50,5),SPRCAL(2),APRIN(50,5),APRCAL(2),
     3             REAIN(50,5),REACAL(2),TININ(50,3),DOXCAL(2),
     4             ALGIN(50,17),ALGCAL(6),PHOIN(50,3)
      COMMON/BQUAL/MODBOD,MODDOX,MODREA,MODTIN,MODPHO,MODALG,I,J,
     1             TEMPR,DEPTH,IZRCON(16)
C
C
C****************************** CHECK DO CONCENTRATION *************************
C
      IF (IZRCON(16)) 200,200,100
C
C***************************** DO CONCENTRATION IS NOT ZERO ********************
C
  100 DLDDT=-BENCAL(1)*RLD+BODIN(I,2)*RLC
C
C******************************  CHECK BENTHIC BOD CONCENTRATION TO  ***********
C                                    DETERMINE IF SCOUR IS POSSIBLE
C
      IF (IZRCON(1)) 300,300,110
  110 DLDDT= DLDDT -BODIN(I,3)
      GO TO 300
C
C****************************** DO CONCENTRATION IS ZERO  **********************
C
  200 DLDDT= +BODIN(I,2)*RLC -DOXCAL(2)*BENCAL(1)*RLD
C
C**************************** CHECK FOR ZERO CONCENTRATIONS ********************
      IF (IZRCON(1)) 300,300,210
C
  210 DLDDT=DLDDT -BODIN(I,3)
C
  300 RETURN
      END
      SUBROUTINE TOC(CT,CR,RLC,DCTDT,DCRDT)
C
C
C         THIS SUBROUTINE CALCULATES THE RATE OF CHANGE OF TOTAL ORGANIC
C         CARBON AND REFRACTORY ORGANIC CARBON BASED ON FIRST ORDER
C         REACTIONS.
C
C         THE FOLLOWING NOMENCLATURE IS USED
C
C
C
C              TOCIN(I,2).....SEDIMENTATION CONSTANT FOR REF OC
C              TOCIN(I,3).....CONSTANT RELATING BOD TO TOC
C              TOCIN(I,4).....SCOUR TERM FOR BIO TOC
C              TOCIN(I,5).....SCOUR TERM FOR REF OC
C              TOCCAL(1)......DEOXYGENATION CONSTANT FOR TOC
C
      COMMON/ALL/MAXCON,IDOCNT,NJ,HOURS,ICYCLE,KCON
      COMMON/AQUAL/TOCIN(50,6),TOCCAL(2),BENIN(50,2),BENCAL(2),
     1             BODIN(50,6),BODCAL(2),TOXIN(50,3),TOXCAL(2),
     2             SPRIN(50,5),SPRCAL(2),APRIN(50,5),APRCAL(2),
     3             REAIN(50,5),REACAL(2),TININ(50,3),DOXCAL(2),
     4             ALGIN(50,17),ALGCAL(6),PHOIN(50,3)
      COMMON/BQUAL/MODBOD,MODDOX,MODREA,MODTIN,MODPHO,MODALG,I,J,
     1             TEMPR,DEPTH,IZRCON(16)
C
C****************************** CHECK DO CONCENTRATION ***************************
C
      IF (IZRCON(16)) 200,200,100
C
C****************************** DO CONCENTRATION IS NOT ZERO ********************
C
  100 DCTDT= -(TOCCAL(1)+TOCIN(I,2))*TOCIN(I,3)*CT -TOCIN(I,2)*CR
     1        +TOCIN(I,4)+TOCIN(I,5)
      DCRDT= -TOCIN(I,2)+TOCIN(I,5)
      GO TO 300
C
C****************************** DO CONCENTRATION IS ZERO *************************
C
  200 DCTDT= -(DOXCAL(2)*TOCCAL(1)+ TOCIN(I,2))*TOCIN(I,3)*CT
     1        -TOCIN(I,2)*CR +TOCIN(I,4) +TOCIN(I,5)
      DCRDT= -TOCIN(I,2) +TOCIN(I,5)
C
C****************************** CHECK FOR ZERO CONCENTRATIONS *******************
C
  300 IF (IZRCON(8).LT.0) DCTDT=0.
      IF (IZRCON(7).LT.0) DCRDT=0.
      RETURN
      END
      SUBROUTINE TOX(TC,DTCDT)
C
C         THIS SUBROUTINE CALCULATES THE RATE OF CHANGE OF A TOXIC
C         COMPOUND USING AN  NTH - ORDER EQUATION
C
C         THE FOLLOWING NOMENCLATURE IS USED
C
C              TOXIN(I,2).....ORDER OF DECAY, N
C              TOXCAL(1)......DECAY CONSTANT, A
C
C
      COMMON/ALL/MAXCON,IDOCNT,NJ,HOURS,ICYCLE,KCON
      COMMON/AQUAL/TOCIN(50,6),TOCCAL(2),BENIN(50,2),BENCAL(2),
     1              BODIN(50,6),BODCAL(2),TOXIN(50,3),TOXCAL(2),
     2              SPRIN(50,5),SPRCAL(2),APRIN(50,5),APRCAL(2),
     3              REAIN(50,5),REACAL(2),TININ(50,3),DOXCAL(2),
     4              ALGIN(50,17),ALGCAL(6),PHOIN(50,3)
      COMMON/EQUAL/MODBOD,MODDOX,MODREA,MODTIN,MODPHO,MODALG,I,J,
     1              TEMPR,DEPTH,IZRCON(16)
C
C
C****************************** CHECK FOR ZERO TOXIC CONCENTRATION ***************
C
      IF (TC) 200,200,100
C
C****************************** TOXIC CONCENTRATION IS POSITIVE *****************
C
  100 DTCDT= -TOXCAL(1)*TC**TOXIN(I,2)
      GO TO 300
C
C****************************** TOXIC CONCENTRATION IS ZERO   *******************
C
  200 DTCDT=0.
C
C****************************** CHECK FOR ZERO CONCENTRATION  *******************
C
  300 IF (IZRCON(13).LT.0) DTCDT=0.
C
      RETURN
      END
      SUBROUTINE SPR(P)
C
C         THIS SUBROUTINE CALCULATES THE DO PRODUCTION OR USE RATE DUE
C         TO SUSPENDED PHYTOPLANKTON.  THREE MODELS ARE AVAILABLE
C
C              MODDOX
C                1          RATE IS PROPORTIONAL TO PHYTOPLANKTON DENSITY
C                2          RATE IS INDEPENDENT OF PHYTOPLANKTON DENSITY
C                3          RATE IS ZERO
C
C         THE FOLLOWING NOMENCLATURE IS USED
C
C              SPRIN(I,1).....FIRST TERM CONSTANT
C              SPRIN(I,2).....PERIOD
C              SPRIN(I,3).....FIRST TERM PHASE ANGLE
C              SPRIN(I,4).....SECOND TERM CONSTANT
C              SPRIN(I,5).....SECOND TERM  PHASE ANGLE
C
C
      COMMON/ALL/MAXCON,IDOCNT,NJ,HOURS,ICYCLE,KCON
      COMMON/AQUAL/TOCIN(50,6),TOCCAL(2),BENIN(50,2),BENCAL(2),
     1             BODIN(50,6),BODCAL(2),TOXIN(50,3),TOXCAL(2),
     2             SPRIN(50,5),SPRCAL(2),APRIN(50,5),APRCAL(2),
     3             REAIN(50,5),REACAL(2),TININ(50,3),DOXCAL(2),
     4             ALGIN(50,17),ALGCAL(6),PHOIN(50,3)
      COMMON/EQUAL/MODBOD,MODDOX,MODREA,MODTIN,MODPHO,MODALG,I,J,
     1             TEMPR,DEPTH,IZRCON(16)
C
C
C***************************** CHECK MODEL TO BE USED *************************
C
      GO TO (100,200,300),MODDOX
C
C***************************** PHYTOPLANKTON MODEL CHOSEN *********************
C
  100 SPRCAL(1)=(SPRIN(I,1)*COS(SPRIN(I,2)*HOURS+SPRIN(I,3))
     1         +SPRIN(I,4)*COS(SPRIN(I,2)*2*HOURS+SPRIN(I,5)))*P
      GO TO 400
C
C****************************** INDEPENDENT MODEL CHOSEN  *********************
C
  200 SPRCAL(1)= SPRIN(I,1)*COS(SPRIN(I,2)*HOURS+SPRIN(I,3))
     1         +SPRIN(I,4)*COS(SPRIN(I,2)*2*HOURS+SPRIN(I,5))
      GO TO 400
C
C***************************** ZERO VALUE MODEL CHOSEN  ***********************
C
  300 SPRCAL(1)=0
C
  400 RETURN
      END
      SUBROUTINE  APR
C
C         THIS SUBROUTINE CALCULATES THE DO PRODUCTION OR USE DUE TO
C         ATTACHED ALGAE AND AQUATIC PLANTS.  THE CALCULATION IS BASED
C         ON THE SUM OF TWO COS TERMS.  THERE ARE TWO MODELS AVAILABLE
C
C              MODDOX
C                1,2.....COS MODEL
C                3 ......ZERO MODEL
C
C         THE FOLLOWING NOMENCLATURE IS USED
C
C              APRIN(I,1).....FIRST TERM CONSTANT
C              APRIN(I,2).....PERIOD
C              APRIN(I,3).....FIRST TERM PHASE ANGLE
C              APRIN(I,4).....SECOND TERM CONSTANT
C              APRIN(I,5).....SECOND TERM PHASE ANGLE
C
C
      COMMON/ALL/MAXCON,IDOCNT,NJ,HOURS,ICYCLE,KCON
      COMMON/AQUAL/TOCIN(50,6),TOCCAL(2),BENIN(50,2),BENCAL(2),
     1             BODIN(50,6),BODCAL(2),TOXIN(50,3),TOXCAL(2),
     2             SPRIN(50,5),SPRCAL(2),APRIN(50,5),APRCAL(2),
     3             REAIN(50,5),REACAL(2),TININ(50,3),DOXCAL(2),
     4             ALGIN(50,17),ALGCAL(6),PHOIN(50,3)
      COMMON/MQUAL/MODDOD,MODDOX,MODREA,MODTIN,MODPHO,MODALG,I,J,
     1             TEMPR,DEPTH,IZRCON(16)
C
C
C****************************** CHECK MODEL TO BE USED  *************************
C
      GO TO (100,100,200),MODDOX
C
C****************************** COS MODEL  **************************************
C
  100 APRCAL(1)= APRIN(I,1)*COS(APRIN(I,2)*HOURS+APRIN (I,3))
     1          +APRIN(I,4)*COS(APRIN(I,2)*2*HOURS+APRIN(I,5))
      GO TO 300
C
C****************************** ZERO MODEL **************************************
C
  200 APRCAL(1)=0.
C
  300 RETURN
      END
      SUBROUTINE  TIN(C1,C2,C3,C4,P,Z,DC1DT,DC2DT,DC3DT,DC4DT)
C
C        THIS SUBROUTINE CALCULATES THE  RATE OF CHANGE OF FOUR
C        COMPONENTS OF NITROGEN BASED ON FIRST ORDER REACTIONS.  THE
C        FOLLOWING MODELS ARE AVAILABLE
C
C             MODTIN
C               1  .....ALGAL NITROGEN MODEL
C               2  .... AMMONIA - NITRATE ONLY MODEL
C
C        THE FOLLOWING NOMENCLATURE IS USED
C
C             TININ(I,1). ...RATE CONSTANT FROM NH3 TO NO2 (MODTIN 1)
C             TININ(I,1).....RATE CONSTANT FROM NH3 TO NO3 (MODTIN 2)
C             TININ(I,2).....RATE CONSTANT FROM NO2 TO NO3
C             TININ(I,3).....RATE CONSTANT FROM ORGANIC-N TO NH3
C             C1 ............NH3 CONCENTRATION
C             C2 ............NO2 CONCENTRATION
C             C3 ............NO3 CONCENTRATION
C             C4 ............ORGANIC-N CONCENTRATION
C
C
      COMMON/ALL/NXXCON,IDAGNT,NJ,HOURS,ICYCLE,KCON
      COMMON/WQUAL/TOCIN(50,6),TOCCAL(2),BENIN(50,2),BENCAL(2),
     1            BODIN(50,6),BODCAL(2),TOXIN(50,3),TOXCAL(2),
     2            SPRIN(50,5),SPRCAL(2),AMRIN(50,5),AMRCAL(2),
     3            REAIN(50,5),REACAL(2),TININ(50,3),DOXCAL(2),
     4            ALGIN(50,17),ALGCAL(6),PHOIN(50,3)
      COMMON/WQUAL/MODMOD,MODDOX,MODREA,MODTIN,MODPHO,MODALA,I,J,
     1            TEMPR,DEPTH,IZRCON(16)
C
C
C************************************ SELECT NITROGEN MODEL ****************************
C
      GO TO (100,200),MODTIN
C
C************************************ ALGAL NITROGEN MODEL SELECTED ********************
C                                    CHECK FOR ZERO DO CONCENTRATION
C
  100 CTEMP=C1+C3
      IF (CTEMP.GT..0000001) GO TO 110
      CTEMP=1
  110 IF (IZRCON(16)) 150,150,120
C
C************************************ DO CONCENTRATION IS NOT ZERO  *******************
C
  120 DC1DT=-TININ(I,1)*C1+TININ(I,3)*C4-ALGCAL(1)*P*ALGIN(I,12)*C1/
     1        (CTEMP)
      DC2DT=-TININ(I,2)*C2+TININ(I,1)*C1
      DC3DT=TININ(I,2)*C2-ALGCAL(1)*P*ALGIN(I,12)*C3/(CTEMP)
      DC4DT=-TININ(I,3)*C4 +ALGCAL(2)*P*ALGIN(I,12) +(ALGCAL(4)
```

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```
     1        -ALGCAL(3))*Z*ALGIN(I,15)
      GO TO 300
C
C****************************** DO CONCENTRATION IS ZERO ************************
C
  150 DC1DT= -ALGCAL(1)*P*ALGIN(I,12)*C1/(CTEMP)
      DC2DT=0.
      DC3DT= -ALGCAL(1)*P*ALGIN(I,12)*C3/(CTEMP)
      DC4DT= ALGCAL(2)*P*ALGIN(I,12) +(ALGCAL(4)-ALGCAL(3))*Z
     1        *ALGIN(I,15)
      GO TO 300
C
C****************************** AMMONIA - NITRATE ONLY MODEL.    *****************
C                               CHECK FOR ZERO DO CONCENTRATION
C
  200 IF (IZRCON(16)) 250,250,210
C
C****************************** DO CONCENTRATION IS NOT ZERO ********************
C
  210 DC1DT= -TININ(I,2)*C1
      DC2DT= 0.
      DC3DT= +TININ(I,2)*C1
      DC4DT=0
      GO TO 300
C
C****************************** DO CONCENTRATION IS ZERO  ***********************
C
  250 DC1DT=0.
      DC2DT=0.
      DC3DT=0.
      DC4DT=0.
C
C****************************** CHECK FOR ZERO CONCENTRATIONS  ******************
C
C
  300 IF (IZRCON(9).LT.0) DC1DT=0.
      IF (IZRCON(10).LT.0) DC2DT=0.
      IF (IZRCON(11).LT.0) DC3DT=0.
      IF (IZRCON(12).LT.0) DC4DT=0.
C
      RETURN
      END
      SUBROUTINE PHO(D1,D2,D3,P,Z,DD1DT,DD2DT,DD3DT)
C
C         THIS SUBROUTINE CALCULATES THE RATE OF CHANGE OF THREE
C         COMPONENTS OF PHOSPHORUS BASED ON FIRST ORDER REACTIONS.
C         THE FOLLOWING MODELS ARE AVAILABLE
C
C              MODPHO
C                1         ALGAL PHOSPHORUS MODEL
C                2         FIRST ORDER DECAY MODEL
C                3         SECOND ORDER DECAY MODEL
C
C         THE FOLLOWING NOMENCLATURE IS USED
C
C              PHOIN(I,1).....RATE CONSTANT FROM SOLUBLE  TO SEDIMENT
C              PHOIN(I,2).....RATE CONSTANT FROM SEDIMENT TO SOLUBLE
C              PHOIN(I,3).....RATE CONSTANT FROM ORGANIC TO SOLUBLE
C              D1 ............SOLUBLE PHOSPHORUS CONCENTRATION
C              D2 ............SEDIMENT PHOSPHORUS CONCENTRATION
C              D3 ............ORGANIC PHOSPHORUS CONCENTRATION
C
C
      COMMON/ALL/MAXCON,IDUCNT,NJ,HOURS,ICYCLE,KCON
      COMMON/AQUAL/TOCIN(50,6),TOCCAL(2),BENIN(50,2),BENCAL(2),
     1             BODIN(50,6),BODCAL(2),TOXIN(50,3),TOXCAL(2),
     2             SPRIN(50,5),SPRCAL(2),APRIN(50,5),APRCAL(2),
     3             REAIN(50,5),REACAL(2),TININ(50,3),DOXCAL(2),
     4             ALGIN(50,17),ALGCAL(6),PHOIN(50,3)
      COMMON/DQUAL/MODBOD,MODDOX,MODREA,MODTIN,MODPHO,MODALG,I,J,
     1             TEMPR,DEPTH,IZRCON(16)
C
C
C***************************** SELECT PHOSPHORUS MODEL *************************
C
      GO TO (100,200,300),MODPHO
C
C***************************** ALGAL PHOSPHORUS MODEL SELECTED ******************
C                              CHECK DO CONCENTRATION
  100 IF (IZRCON(16)) 120,120,110
C
C***************************** DO CONCENTRATION IS NOT ZERO ********************
C
  110 DD1DT= -PHOIN(I,1)*D1 +PHOIN(I,2)*D2 +PHOIN(I,3)*D3
     1       -ALGCAL(1)*P*ALGIN(I,13)
      DD2DT= -PHOIN(I,2)*D2 +PHOIN(I,1)*D1
      DD3DT= -PHOIN(I,3)*D3 + ALGCAL(2)*P*ALGIN(I,13)
     1       +(ALGCAL(4)-ALGCAL(3))*Z*ALGIN(I,14)
      GO TO 400
C
C***************************** DO CONCENTRATION IS ZERO ************************
C
  120 DD1DT= -PHOIN(I,1)*D1 +PHOIN(I,2)*D2 +PHOIN(I,3)*D3
```

```
     1        -ALOCAL(1)*P*ALOIN(I,13)
      DO2DT= -PHOIN(I,2)*D2 +PHOIN(I,1)*D1
      DO3DT= ALOCAL(2)*P*ALOIN(I,13) + (ALOCAL(4)-ALOCAL(3))*Z
     1        *ALOIN(I,14)
      GO TO 400
C
C****************************** FIRST ORDER PHOSPHORUS MODEL ********************
C
  200 DO1DT= -PHOIN(I,1)*D1 +PHOIN(I,2)*D2
      DO2DT= -PHOIN(I,2)*D2 +PHOIN(I,1)*D1
      DO3DT=0.
      GO TO 400
C
C****************************** SECOND ORDER MODEL  ******************************
C
  300 DO1DT= -PHOIN(I,1)*D1*D1
      DO2DT=0.
      DO3DT=0.
C
C****************************** CHECK FOR ZERO CONCENTRATIONS ********************
C
  400 IF (IZRCON(2).LT.0) DO2DT=0.
      IF (IZRCON(3).LT.0) DO1DT=0.
      IF (IZRCON(4).LT.0) DO3DT=0.
C
      RETURN
      END



C     PROGRAM REPRNT
C
C PROGRAM TO ALLOW REPRINTING OF THE QUALITY OUTPUT AND PUNCHING OF RESTART DECK
C
      DIMENSION C(400,16)
C
      READ(5,1) NJ,NOSART,NOTCYC,NOCYC,PERIOD,DELTO
 1    FORMAT(4I5,2F10.4)
      IUNIT=7
      CALL       PRINT(    C,NOSART,NOTCYC,IUNIT,PERIOD,DELTO,NOCYC,NJ)
      CALL EXIT
      STOP
      END
```

RESERVOIR MODELING CODES

Three computer programs, CLIMA, TERMA, and AQUA, have been assembled for use in thermal, hydraulic, and quality simulations of impoundments and reservoirs. Appendix B is a general description of the individual programs (e.g., card input, program functions, and interface). The coding aspects of the reservoir simulation programs are described in this section.

Thermal Hydraulic Code

The computer codes CLIMA and TERMA are amended and improved versions of the EPA version of the WRE multi-segment deep reservoir model. Program modifications include generalized input models, data checking, and line-printer plotting. Several coding and logic errors in the computational subroutines of the original program have also been corrected.

The CLIMA program, which basically consists of a driver program and 8 auxiliary subroutines, prepares meteorologic and hydraulic data files which may be used repeatedly for simulations of intermediate or extended time periods. Thus the program must be executed independently of the other codes. Figure C-32 is a flowchart of the CLIMA program. Flowcharts for the individual subroutines and variable definitions are available in Reference C-2; detailed descriptions of the individual subroutines are included in the program listing and will not be reproduced here.

Thermal and hydraulic regimes of a reservoir are predicted with the TERMA program. Single or multi-segment representations of a reservoir may be used. A driver program is used to read and print all input card images and establishes the calling sequence to 7 computational subroutines. A general flowchart of TERMA is presented in Figure C-33. Flowcharts for the individual subprograms and FORTRAN variable definitions are available in Reference C-2. Detailed descriptions of the various subprograms are included in the program listing and will not be reproduced here. Applications of the original computer code are well documented in References C-3 and C-4.

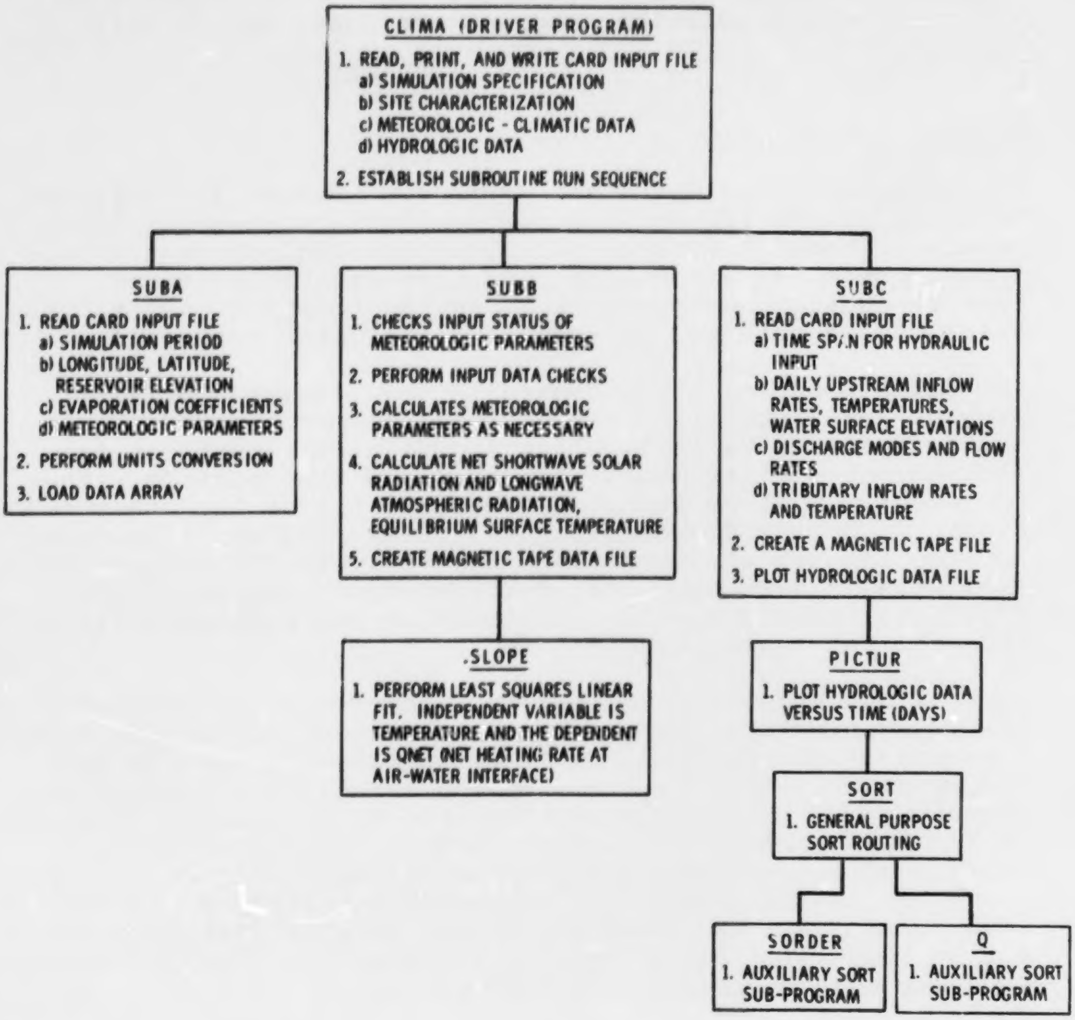
CLIMA (DRIVER PROGRAM)
1. READ, PRINT, AND WRITE CARD INPUT FILE
a) SIMULATION SPECIFICATION
b) SITE CHARACTERIZATION
c) METEOROLOGIC - CLIMATIC DATA
d) HYDROLOGIC DATA
2. ESTABLISH SUBROUTINE RUN SEQUENCE
SUBA
1. READ CARD INPUT FILE
a) SIMULATION PERIOD
b) LONGITUDE, LATITUDE, RESERVOIR ELEVATION
c) EVAPORATION COEFFICIENTS
d) METEOROLOGIC PARAMETERS
2. PERFORM UNITS CONVERSION
3. LOAD DATA ARRAY
SUBB
1. CHECKS INPUT STATUS OF METEOROLOGIC PARAMETERS
2. PERFORM INPUT DATA CHECKS
3. CALCULATES METEOROLOGIC PARAMETERS AS NECESSARY
4. CALCULATE NET SHORTWAVE SOLAR RADIATION AND LONGWAVE ATMOSPHERIC RADIATION, EQUILIBRIUM SURFACE TEMPERATURE
5. CREATE MAGNETIC TAPE DATA FILE
SUBC
1. READ CARD INPUT FILE
a) TIME SPAN FOR HYDRAULIC INPUT
b) DAILY UPSTREAM INFLOW RATES, TEMPERATURES, WATER SURFACE ELEVATIONS
c) DISCHARGE MODES AND FLOW RATES
d) TRIBUTARY INFLOW RATES AND TEMPERATURE
2. CREATE A MAGNETIC TAPE FILE
3. PLOT HYDROLOGIC DATA FILE
SLOPE
1. PERFORM LEAST SQUARES LINEAR FIT. INDEPENDENT VARIABLE IS TEMPERATURE AND THE DEPENDENT IS QNET (NET HEATING RATE AT AIR-WATER INTERFACE)
PICTUR
1. PLOT HYDROLOGIC DATA VERSUS TIME (DAYS)
SORT
1. GENERAL PURPOSE SORT ROUTING
SORDER
1. AUXILIARY SORT SUB-PROGRAM
Q
1. AUXILIARY SORT SUB-PROGRAM

FIGURE C-32. FLOWCHART OF CLIMA - GENERAL METEOROLOGIC AND HYDRAULIC DATA INPUT CODE

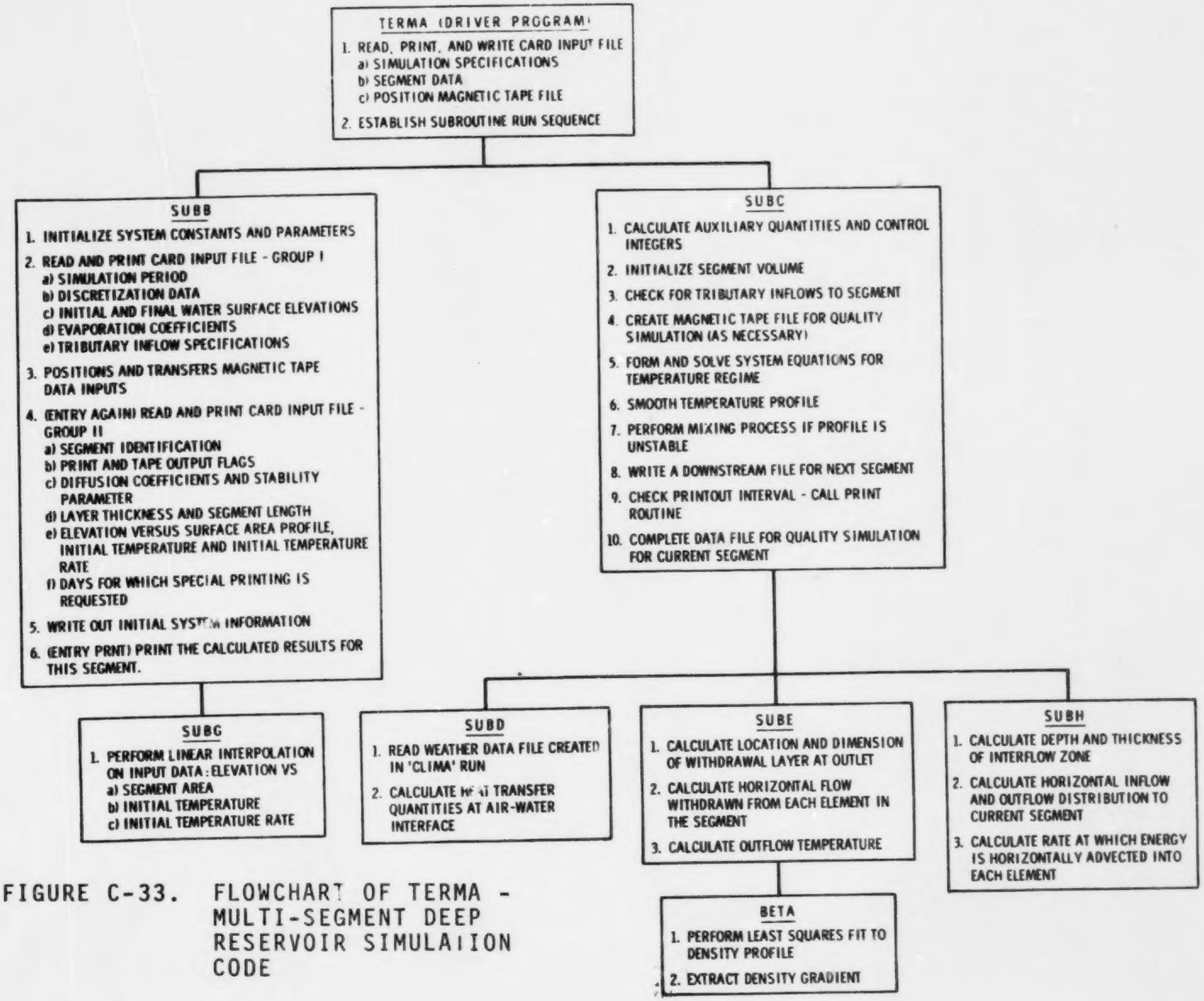
TERMA (DRIVER PROGRAM)
1. READ, PRINT, AND WRITE CARD INPUT FILE
a) SIMULATION SPECIFICATIONS
b) SEGMENT DATA
c) POSITION MAGNETIC TAPE FILE
2. ESTABLISH SUBROUTINE RUN SEQUENCE
SUBB
1. INITIALIZE SYSTEM CONSTANTS AND PARAMETERS
2. READ AND PRINT CARD INPUT FILE - GROUP I
a) SIMULATION PERIOD
b) DISCRETIZATION DATA
c) INITIAL AND FINAL WATER SURFACE ELEVATIONS
d) EVAPORATION COEFFICIENTS
e) TRIBUTARY INFLOW SPECIFICATIONS
3. POSITIONS AND TRANSFERS MAGNETIC TAPE DATA INPUTS
4. (ENTRY AGAIN) READ AND PRINT CARD INPUT FILE - GROUP II
a) SEGMENT IDENTIFICATION
b) PRINT AND TAPE OUTPUT FLAGS
c) DIFFUSION COEFFICIENTS AND STABILITY PARAMETER
d) LAYER THICKNESS AND SEGMENT LENGTH
e) ELEVATION VERSUS SURFACE AREA PROFILE, INITIAL TEMPERATURE AND INITIAL TEMPERATURE RATE
f) DAYS FOR WHICH SPECIAL PRINTING IS REQUESTED
5. WRITE OUT INITIAL SYSTEM INFORMATION
6. (ENTRY PRNT) PRINT THE CALCULATED RESULTS FOR THIS SEGMENT.
SUBC
1. CALCULATE AUXILIARY QUANTITIES AND CONTROL INTEGERS
2. INITIALIZE SEGMENT VOLUME
3. CHECK FOR TRIBUTARY INFLOWS TO SEGMENT
4. CREATE MAGNETIC TAPE FILE FOR QUALITY SIMULATION (AS NECESSARY)
5. FORM AND SOLVE SYSTEM EQUATIONS FOR TEMPERATURE REGIME
6. SMOOTH TEMPERATURE PROFILE
7. PERFORM MIXING PROCESS IF PROFILE IS UNSTABLE
8. WRITE A DOWNSTREAM FILE FOR NEXT SEGMENT
9. CHECK PRINTOUT INTERVAL - CALL PRINT ROUTINE
10. COMPLETE DATA FILE FOR QUALITY SIMULATION FOR CURRENT SEGMENT
SUBG
1. PERFORM LINEAR INTERPOLATION ON INPUT DATA: ELEVATION VS
a) SEGMENT AREA
b) INITIAL TEMPERATURE
c) INITIAL TEMPERATURE RATE
SUBD
1. READ WEATHER DATA FILE CREATED IN 'CLIMA' RUN
2. CALCULATE HEAT TRANSFER QUANTITIES AT AIR-WATER INTERFACE
SUBE
1. CALCULATE LOCATION AND DIMENSION OF WITHDRAWAL LAYER AT OUTLET
2. CALCULATE HORIZONTAL FLOW WITHDRAWN FROM EACH ELEMENT IN THE SEGMENT
3. CALCULATE OUTFLOW TEMPERATURE
SUBH
1. CALCULATE DEPTH AND THICKNESS OF INTERFLOW ZONE
2. CALCULATE HORIZONTAL INFLOW AND OUTFLOW DISTRIBUTION TO CURRENT SEGMENT
3. CALCULATE RATE AT WHICH ENERGY IS HORIZONTALLY ADVECTED INTO EACH ELEMENT
BETA
1. PERFORM LEAST SQUARES FIT TO DENSITY PROFILE
2. EXTRACT DENSITY GRADIENT

FIGURE C-33. FLOWCHART OF TERMA - MULTI-SEGMENT DEEP RESERVOIR SIMULATION CODE

Quality Simulation Code

The reservoir quality simulation code AQUA is, by design, a simple, modular program. Individual component subroutines can be modified, interchanged or replaced for specific applications, as can quality models and computational algorithms. The main calculational loops are identified and described in the program listing. Much of the programming in AQUA has been designed in anticipation of future extensions and generalizations of the code (e.g., multi-segment, variable layer thickness, space variable model coefficients, etc.). Figure C-34, a flowchart of the quality simulation code, depicts the basic functions of individual routines. A list of program variables and their definitions is found in Table C-3.

Remarks

Considerable effort has been devoted to commenting on individual subroutines; variable definitions not included in Table C-3 may be found in the program listing. It is hoped that those familiar with basic FORTRAN coding will easily master the program structure and alter it as necessary.

All three computer codes were compiled and tested on a UNIVAC 1108 with very satisfactory results. Program source listings of CLIMA, TERMA, and AQUA are presented at the end of this section in Figures C-35, C-36, and C-37.

CONCLUSION

Considerable effort has been devoted to the computer implementation aspect of this project, including emphasis on a modular approach to programming. The programs listed in this report are basically UNIVAC 1108 dependent. However, it is envisioned that conversion to other computer systems will require relatively little effort. A main system difference between the UNIVAC and other computers is that core initialization to -0.0 is automatic. EPA personnel (Reference E-5) have recently converted the EXPLORE-I codes for use on IBM equipment.

At this writing, newer and improved versions of the EXPLORE-I codes are being developed for implementation on a CDC 6600, CYBER 70 computer. A number of improvements in the river and estuary hydraulic module and the Deep Reservoir modules are being completed. These up-to-date program listings and source decks can be obtained from EPA or Battelle-Northwest.

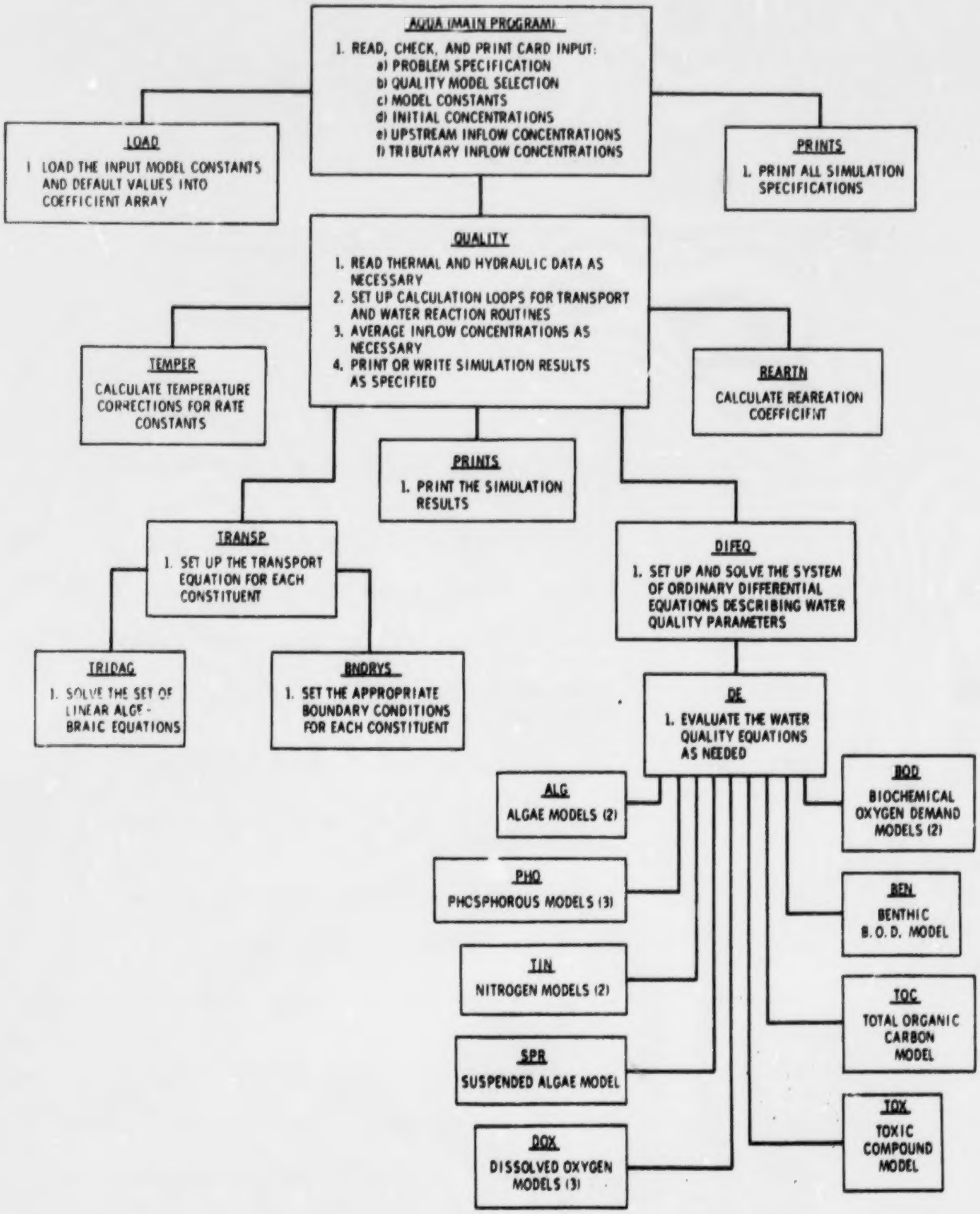
AQUA (MAIN PROGRAM)
1. READ, CHECK, AND PRINT CARD INPUT:
a) PROBLEM SPECIFICATION
b) QUALITY MODEL SELECTION
c) MODEL CONSTANTS
d) INITIAL CONCENTRATIONS
e) UPSTREAM INFLOW CONCENTRATIONS
f) TRIBUTARY INFLOW CONCENTRATIONS
LOAD
1 LOAD THE INPUT MODEL CONSTANTS AND DEFAULT VALUES INTO COEFFICIENT ARRAY
PRINTS
1. PRINT ALL SIMULATION SPECIFICATIONS
QUALITY
1. READ THERMAL AND HYDRAULIC DATA AS NECESSARY
2. SET UP CALCULATION LOOPS FOR TRANSPORT AND WATER REACTION ROUTINES
3. AVERAGE INFLOW CONCENTRATIONS AS NECESSARY
4. PRINT OR WRITE SIMULATION RESULTS AS SPECIFIED
TEMPER
CALCULATE TEMPERATURE CORRECTIONS FOR RATE CONSTANTS
REARTN
CALCULATE REAREATION COEFFICIENT
PRINTS
1. PRINT THE SIMULATION RESULTS
TRANSP
1. SET UP THE TRANSPORT EQUATION FOR EACH CONSTITUENT
DIFEQ
1. SET UP AND SOLVE THE SYSTEM OF ORDINARY DIFFERENTIAL EQUATIONS DESCRIBING WATER QUALITY PARAMETERS
TRIDAG
1. SOLVE THE SET OF LINEAR ALGEBRAIC EQUATIONS
BNDRYS
1. SET THE APPROPRIATE BOUNDARY CONDITIONS FOR EACH CONSTITUENT
DE
1. EVALUATE THE WATER QUALITY EQUATIONS AS NEEDED
ALG
ALGAE MODELS (2)
BOD
BIOCHEMICAL OXYGEN DEMAND MODELS (2)
PHO
PHOSPHOROUS MODELS (3)
BEN
BENTHIC B.O.D. MODEL
TIN
NITROGEN MODELS (2)
TOC
TOTAL ORGANIC CARBON MODEL
SPR
SUSPENDED ALGAE MODEL
TOX
TOXIC COMPOUND MODEL
DOX
DISSOLVED OXYGEN MODELS (3)

FIGURE C-34. FLOWCHART OF AQUA, RESERVOIR QUALITY SIMULATION CODE

TABLE C-3

VARIABLE DEFINITION FOR RESERVOIR QUALITY CODE

Variable Name	Location	Description	Units
A	REARTN	Constant for reaeration formula	
A(J)	TRANSP TRIDAG	Coefficient array for tridiagonal algorithm	
ALGCAL	ALG	Calculated algae concentrations	mg/ℓ
ALGIN	ALG	Algae model coefficients	
AREA(J)	TRANSP	Horizontal section area for layer J	Sq. ft.
A1,A2,A3,A4	QUALTY	Coefficients for D.O. saturation formula	
B	REARTN	Constant for reaeration formula	
B(J)	TRANSP TRIDAG	Coefficient array for tridiagonal algorithm	
BENCAL	BEN	Calculated benthic concentration	g/m^2
BENIN	BEN	Benthic model coefficients	
BETA	TRIDAG	Coefficient array for tridiagonal algorithm	
BODCAL	BOD	Calculated BOD concentrations	mg/ℓ
BODIN	BOD	B.O.D. model coefficients	
C(J,K)	AQUA	Predicted quality concentrations	
C(J)	TRANSP TRIDAG	Coefficient array for tridiagonal algorithm	
CARDS	AQUA	Array for input/output of card image data	
CCC(J)	TRANSP	Temporary storage	
CCIN(J,K)	AQUA	Inflow concentrations	

TABLE C-3 (Continued)

Variable Name	Location	Description	Units
COEF(J)	AQUA	Temporary storage	
CONC	AQUA	Temporary storage	
CTEMP	TIN	Temporary storage	
CTRIB(K)	AQUA	Tributary inflow concentrations	
D(J)	TRANSP TRIDAG	Coefficient array for tridiagonal algorithm	
DAYS	AQUA	First day in simulation period	
DELT	PRINTS TRANSP	Simulation time step	days
DELTD	AQUA	Simulation time step	days
DELTH	AQUA	Simulation time step	hours
DELZ	AQUA	Standard element thickness	m.
DELZT	QUALTY	Thickness of uppermost element	m.
DEPTH	AQUA	Light extinction depth	m.
DIFUSY	AQUA	Effective diffusion constant	m^2/sec.
DOXCAL	DOX	Calculated D.O. concentration	mg/ℓ
DTEMP	ALG	Light extinction depth	m.
DZ	TRANSP	Standard element thickness	m.
DZT	TRANSP	Thickness of uppermost element	m.
F(K)	DE	Function evaluations of first order reaction terms	
GAMA(J)	TRIDAG	Coefficient array for tridiagonal algorithm	
HOURS	QUALTY	Time increment counter	hours
I	COMMON	Segment index	
I	DIFEQ	Number of time subintervals	

TABLE C-3 (Continued)

Variable Name	Location	Description	Units
ID	AQUA	Input flag for parameter identification	
IDAY	AQUA	First day of simulation period	
IJK	QUALTY	Segment indice	
IPRINT	AQUA	Time print frequency	
ISUM	AQUA	Counter for card input	
IZRCHK	COMMON	Flag for designation of negative or zero parameter values	
IZRCON	COMMON	Flag storage array	
J	COMMON	Element index	
JKI	QUALTY	Segment index	
K	COMMON	Indice of the k^{th} constituent	
LDAY	AQUA	Last day of simulation period	
LIMIT	AQUA	Arrays containing the number of quality model coefficients per parameter	
LOGIC	AQUA	Flag for selecting simulation mode (with or without water quality reactions)	
LOWEST	AQUA	Lowest element with upstream inflow	
MAXCON	COMMON	Maximum of quality constituents (16)	
MM	COMMON	Maximum number of elements per segment	
MODALG	COMMON	Flag for algae model selection (2)	
MODBOD	COMMON	Flag for B.O.D. model selection (2)	
MODDOX	COMMON	Flag for D.O. model selection (3)	
MODPHO	COMMON	Flag for phosphorous model selection (3)	

TABLE C-3 (Continued)

Variable Name	Location	Description	Units
MODTIN	COMMON	Flag for nitrogen model selection (2)	
NELEM	TRANSP	Number of elements in segment	
NN	AQUA	Maximum number of segments (1)	
NOLITE	QUALTY	Element index at light extinction depth	
NPRINT	AQUA	Element print frequency	
NSTEP	QUALTY	Total number of time increments to be executed in simulation period	
NSEG	QUALTY	Segment index	
NTRIBS	AQUA	Flag array designating tributary inflows to segment	
NXEQ	QUALTY	Interval at which hydraulics and temperature data is available	
P	ALG	Phytoplankton concentration	
PHOIN	COMMON	Coefficient array for phosphorous models	
QHIN(J)	QUALTY	Horizontal inflow to element J	ft^3/sec
QHOUT(J)	QUALTY	Horizontal outflow from element J	" "
QTRIB	QUALTY	Tributary inflow rate	" "
QV	QUALTY	Vertical flow thru element J	" "
QVIN	QUALTY	Temporary storage	
REACAL	REARTN	Reareation constant	
SORCE(K)	QUALTY	Source term for k^{th} constituent	
SPRCAL	SPR	Calculated suspended algae concentration	
SPRIN	COMMON	Coefficient array for suspended algae models	
SWITCH	AQUA	Flag for selecting input mode	

TABLE C-3 (Continued)

Variable Name	Location	Description	Units
TEMP(J)	QUALTY	Temperature of J element	°C
TEMPR	QUALTY	Temporary storage	°C
TF	DIFEQ	Final integration time	days
TININ	TIN	Coefficient array for nitrogen models	
TITLE	AQUA	Title	
TO	DIFEQ	Initial integration time	days
TOCCAL	TOC	Calculated total organic carbon concentration	mg/ℓ
TOCIN	COMMON	Coefficient array for total organic carbon model	
TOXCAL	TOX	Calculated toxic compound concentration	mg/ℓ
TOXIN	COMMON	Coefficient array for toxic compound model	
VALUE	LOAD	Temporary storage	
WIND	QUALTY	Wind speed	ft/sec
X	DIFEQ	Initial integration time	days
XE	DIFEQ	Final integration time	days
Y	DIFEQ	Temporary storage	
YF	DIFEQ	Temporary storage	

FIGURE C-35. PROGRAM LISTING FOR CLIMA

```
C     CLIMA:
C     GENERALIZED INPUT CODE FOR THE RESERVOIR SIMULATION PROGRAM-TERMA
C
C     COMPONENT ROUTINES :
C     MIF  - METEOROLOGIC INPUT FILE
C     UIF  - UPSTREAM INFLOW FILE
C     OF   - OUTFLOW FILE
C     TIF  - TRIBUTARY INFLOW FILE
C
C     ORIGINALLY PROGRAMMED BY WATER RESOURCES ENGINEERS
C     MODIFIED AND REVISED BY ROBT.  BACA-JANUARY 1972
C     WATER RESOURCES SYSTEMS SECTION, BATTELLE-NORTHWEST
C     P.O. BOX 999,  RICHLAND, WASHINGTON 99352
C
C             MIF :
C     THIS ROUTINE READS A REQUIRED SET OF METEOROLOGIC OBSERVATIONS
C     FROM CARDS, MAKES SPECIFIED UNITS CONVERSIONS, AND WRITES AN
C     OUTPUT FILE ON LOGICAL UNIT 4.  MIFP IS PROGRAMMED TO PREPARE AN
C     ESTIMATE OF THE NET RATE OF SHORT AND LONG WAVE RADIATION, AND
C     AN ESTIMATE OF THE EQUILIBRIUM TEMPERATURE REPRESENTATIVE OF A
C     RESERVOIR'S WATER SURFACE UNDER THE ATMOSPHERIC CONDITIONS
C     SPECIFIED FOR EACH OBSERVATION.  THE PROGRAM CAN ACCEPT UP TO 2920
C     SEPARATE OBSERVATIONS FOR EACH METEOROLOGIC PARAMETER AND STAY
C     WITHIN 32K OF CORE.  ALL METEOROLOGIC DATA NECESSARY FOR INPUT TO
C     MIF IS AVAILABLE FROM THE U.S.  WEATHER BUREAU'S STANDARD DECK
C     NO. 144 - CONTACT DAVE CALLOWAY, NATIONAL WEATHER RECORDS CENTER
C     ASHEVILLE, NORTH CAROLINA, PH. (704) 254-0203
C
C             UIF :
C     THIS FILE CONTAINS THE SYSTEM WATER SURFACE ELEVATIONS AND AVERAGE
C     INFLOW AND INFLOW TEMPERATURES ON A DAILY BASIS.
C
C             OF :
C     THIS FILE PROVIDES THE DATA DESCRIBING THE SYSTEM WITHDRAWALS.
C     THIS DATA USUALLY DESCRIBES THE FLOWS THROUGH THE VARIOUS TUBES,
C     GATES, AND TURBINES AT THE DAM.
C
C             TIF :
C     THIS FILE CONTAINS DATA ON THE QUANTITY AND TEMPERATURE OF FLOWS
C     WHICH ENTER THE SYSTEM BELOW ITS MOST UPSTREAM POINT.   THESE
C     RECORDS ARE READ BY TERMA AS THE SIMULATION MOVES TO THE APPROPRI-
C     ATE RESERVOIR SEGMENT.
C
C
      DIMENSION ITAB(15), CARDS(16)
      PARAMETER NGROUP=2
      DATA TEST/5HEND  /
      CALL SETDR (1,300000,100000,ITAB(1))
      CALL SETDR (2,400000,100000,ITAB(8))
      REWIND 1
      REWIND 2
```

```
C
C         WRITE INPUT CARD IMAGES TO DRUM AND PRINTER
C
      WRITE (6,130)
      WRITE (6,170)
      WRITE (6,140)
      DO 110 I=1,NGROUP
      L=1
100   READ (5,150,END=120) (CARDS(J),J=1,16)
      WRITE (6,160) L,(CARDS(J),J=1,16)
      IF (CARDS(1).EQ.TEST) GO TO 110
      WRITE (I,150) (CARDS(J),J=1,16)
      L=L+1
      GO TO 100
110   CONTINUE
      REWIND 1
      REWIND 2
      CALL SUBA
      CALL SUBB
      CALL SUBC
120   STOP
C
C
130   FORMAT (1H1,//,30X,'RESERVOIR SIMULATION PROGRAM'/35X,'BATTELLE-NO
     1RTHWEST'/28X,'WATER RESOURCES SYSTEMS SECTION'/27X,'P.O. BOX 999,
     2RICHLAND WASHINGTON'//30X,28(1H*)/30X,'*  INPUT DATA CARD IMAGES
     3*'/30X,28(1H*)//)
140   FORMAT (7X,80H12345678901234567890123456789012345678901234567890123456789012
     1345678901234567890123456789O//)
150   FORMAT (16A5)
160   FORMAT (I5,2X,16A5)
170   FORMAT (35X,'INPUT CARD COLUMNS'/7X,'*  1-10  *  11-20  *  21-30
     1*  31-40  *  41-50  *  51-60  *  61-70  *  71-80  *')
      END
      SUBROUTINE SUBA
C
C     THIS SUBROUTINE PERFORMS THE TASK OF INPUTTING THE METEOROLOGIC
C     PARAMETERS, MAKING SPECIFIED UNITS CONVERSIONS, AND PRINTING A
C     COMMENT FOR EACH PARAMETER INPUT.  ALL DATA IS ENTERED FROM THE
C     CARD READER, LOGICAL UNIT 5.  THE OUTPUT FROM THIS ROUTINE IS AN
C     ORDERED SET OF DATA IN THE PROPER UNITS WHICH ARE LATER INPUT TO
C     THE COMPUTATION ROUTINE: TSIP - THERMAL SIMULATION PROGRAM
C
      COMMON/DV/ DATA(2920,7), ALPHA(16), INDEX(8)
      COMMON/NDV/ A, B, IDAY, ITAPE, IYR, LAT, LDAY, LOG, NOBS, PTEMP,
     1 RESEL, SRO, SSO, NGO, NINT
      REAL LAT, LOG
C
C     INITIALIZE NECESSARY VARIABLES
C
      SRO=0.0
      SSO=0.0
      PTEMP=0.0
      DO 100 J=1,8
      INDEX(J)=0
100   CONTINUE
C
C     READ AND WRITE RUN DATA
C
C        INPUT - GROUP I
C
C        CARD 1
C     ALPHA ........TITLE
C        <16A5>
      READ (1,250) ALPHA
      WRITE (6,300) ALPHA
C
C        CARD 2
C     IYR..........YEAR OF THE METEOROLOGIC OBSERVATIONS
C     IDAY.........FIRST JULIAN DAY FOR THE CALCULATIONS
C     LDAY.........FINAL JULIAN DAY FOR THE CALCULATIONS
C     NOBS.........NUMBER OF METEOROLOGIC OBSERVATIONS PER DAY
C     ITAPE........OUTPUT TAPE NUMBER
C        <8I10>
      READ (1,260) IYR,IDAY,LDAY,NOBS,ITAPE
      WRITE (6,310) IYR,IDAY,LDAY,NOBS,ITAPE
      NGO=1
      NINT=NOBS*(LDAY-IDAY+1)
C
C        CARD 3
C     A............EVAPORATION COEFFICIENT (DEFAULT / A=0.0)
C     B............EVAPORATION COEFFICIENT (DEFAULT / B=1.E-10)
C     LAT..........LATITUDE OF SITE
C     LONG.........LONGITUDE OF SITE
C     RESEL........AVERAGE WATER SURFACE ELEVATION
```

```
C        <8E10.0>
      READ (1,290) A,B,LAT,LOG,RESEL
      IF (A.GT.1.0) A=0.0
      IF (B.LE.0.0) B=1.E-10
      WRITE (6,320) A,B,LAT,LOG,RESFL
C
C     READ A METOROLOGIC DATA SET
C
C     INPUT FOR EACH METEOROLOGIC PARAMETER.  THERE WILL BE A MINIMUM
C     OF FOUR SETS OF THIS DATA GROUP.
C
C        CARD 4
C     ID...........PARAMETER IDENTIFICATION FOR UNITS CONVERSION
C     CV...........FIRST CONVERSION FACTOR >
C     CVA..........SECOND CONVERSION FACTOR>  X=A*(XRAW + B) +C
C     CVB..........THIRD CONVERSION FACTOR >
C     LOGIC........SENTRY FOR CONSTANT VALUES
C        <I10.3E10.0,I5>
110   READ (1,280) ID,CV,CVA,CVB,LOGIC
C
C     CHECK ON INPUT STATUS
C
      IF (ID.LE.0) GO TO 240
      IB=ID
      INDEX(ID)=ID
      IF (ID.GT.5) ID=ID-1
      IF (IB.EQ.8) ID=5
C
C        CARD 5
C     DATA.........METEOROLOGIC PARAMETERS:
C                  ID CODE  PARAMETER                 UNITS
C                    1      ATMOSPHERIC PRESSURE      MILLIBARS
C                    2      SKY COVER                 DECIMAL FRACTION
C                    3      WIND SPEED                METERS/SEC
C                    4      DRY BULB AIR TEMPERATURE  CENTIGRADE
C                    5      WET BULB AIR TEMPERATURE  CENTIGRADE
C                    6      DEW POINT TEMPERATURE     CENTIGRADE
C                    7      SHORT WAVE SOLAR RAD.     KCAL/M**2*SEC.
C                    8      RELATIVE HUMIDITY         DECIMAL FRACTION
C        <8E10.0>
      IF (LOGIC.LE.0) GO TO 120
      READ (1,270) DATA(1,ID)
      DO 115 J=NGO,NINT
115   DATA(J,ID)=DATA(1,ID)
      LOGIC=0
      GO TO 130
120   READ (1,270) (DATA(J,ID),J=NGO,NINT)
C     MAKE UNITS CONVERSIONS
C
130   IF (CV.EQ.0.0.AND.SIGN(1.0,CV).LT.0.0) CV=1.00
      DO 140 J=NGO,NINT
      DATA(J,ID) = CV * ( DATA(J,ID) + CVA ) + CVB
```

```
140   CONTINUE
C
C     WRITE OUT COMMENT FOR EACH INPUT
C
      GO TO (150,160,170,180,190,200,210,220), IB
150   WRITE (6,340)
      GO TO 230
160   WRITE (6,350)
      GO TO 230
170   WRITE (6,360)
      GO TO 230
180   WRITE (6,370)
      GO TO 230
190   WRITE (6,380)
      GO TO 230
200   WRITE (6,390)
      GO TO 230
210   WRITE (6,400)
      GO TO 230
220   WRITE (6,410)
230   WRITE (6,330) CV,CVA,CVB
      GO TO 110
C
C     END OF RAW DATA INPUT
C
240   CONTINUE
      RETURN
C
C
250   FORMAT (16A5)
260   FORMAT (8I10)
270   FORMAT (8E10.0)
280   FORMAT (I10,3E10.0,I5)
290   FORMAT (8E10.0)
300   FORMAT (1H1,//,50X,'RESERVOIR SIMULATION PROGRAM'/55X,'BATTELLE-NO
     1RTHWEST'/48X,'WATER RESOURCES SYSTEMS SECTION'/47X,'P.O. BOX 999,
     2RICHLAND WASHINGTON'//20X,16A5//47X,32(1H*)/47X,'*  METEUROLGIC IN
     3PUT ANALYSIS  *'/47X,32(1H*)//)
310   FORMAT (1H0,56X,'YEAR',I10/51X,'FIRST DAY',I10/52X,'LAST DAY',I10/
     157X,'OBS',I10/52X,'TAPE OUT',I10)
320   FORMAT (//59X,1HA,E10.2/59X,1HB,E10.2/52X,'LATITUDE',F10.1/51X,'
     1LONGITUDE',F10.1/51X,'ELEVATION',F10.1)
330   FORMAT (1H+,60X,11HCONVERSIONS1P3E15.3,I10)
340   FORMAT (/,20X,26HATMOSPHERIC PRESSURE INPUT)
350   FORMAT (/,20X,16HCLOUDINESS INPUT)
360   FORMAT (/,20X,16HWIND SPEED INPUT)
370   FORMAT (/,20X,26HDRY BULB TEMPERATURE INPUT)
380   FORMAT (/,20X,26HWET BULB TEMPERATURE INPUT)
390   FORMAT (/,20X,27HDEW POINT TEMPERATURE INPUT)
400   FORMAT (/,20X,32HSHORT WAVE SOLAR RADIATION INPUT)
410   FORMAT (/,20X,23HRELATIVE HUMIDITY INPUT)
      END
      SUBROUTINE SUBB
C
C     THIS SUBROUTINE CALCULATES AND OUTPUTS THE INFORMATION NECESSARY
C     FOR THE FIRST SET OF LOGICAL RECORDS ON THE INPUT FILE.  THE FIRST
C     TASK PERFORMED BY THE ROUTINE IS THE CALCULATION OF ATMOSPHERIC
C     VAPOR PRESSURE, FOLLOWING WHICH A PROCEDURE IS USED TO ESTIMATE
C     THE NET RATE OF SHORT WAVE RADIATION.  THROUGH THE USE OF SUITABLE
C     FORMULAS, THE NET INCOMING SOLAR RADIATION IS EVALUATED AT HOURLY
C     TIME STEPS AND THE POINT VALUES INTEGRATED OVER TIME TO PRODUCE
C     AVERAGE NET INCOMING RADIATION RATES FOR THE SPECIFIED TIME STEP.
C     THE NET RATE OF LONG WAVE ATMOSPHERIC RADIATION IS ESTIMATED
C     DIRECTLY FROM THE AVERAGE CONDITIONS OVER THE OBSERVATION INTERVAL
C     THE FINAL COMPUTATION SECTION PRODUCES AN ESTIMATION OF THE
C     EQUILIBRIUM TEMPERATURE AT A RESERVOIR'S WATER SURFACE UNDER THE
C     EXISTING ATMOSPHERIC CONDITIONS.  THIS VALUE IS PRINTED ON THE
C     OUTPUT BUT NOT WRITTEN ON THE OUTPUT TAPE.  DATA IS OUTPUT TO
C     LOGICAL UNIT 4.
C
      COMMON/NDY/ A, B, IDAY, ITAPE, IYR, LAT, LDAY, LOG, NOBS, PTEMP,
     1  RESEL, SRO, SSO, NGO, NINT
      COMMON/DV/ DATA(2920,7), ALPHA(16), INDEX(8)
      EQUIVALENCE (DATA(1,1),AP(1)), (DATA(1,2),CLD(1),ET(1) ),
     1  (DATA(1,3),WS(1)),(DATA(1,4),DBT(1)), (DATA(1,5),WBT(1),DPT(1),
     2 RELHUM(1)),          (DATA(1,6),QS(1),QNS(1)),
     3  (DATA(1,7),QAT(1),WC(1))
      REAL AP(2920), CLD(2920), WS(2920), DBT(2920), WBT(2920),
     1  DPT(2920), QS(2920), QAT(2920), QNS(2920), WC(2920), EA(2920),
     2  ET(2920), RELHUM(2920), XK(2920), QNET(5), XTEMP(5)
      REAL  LAT, LOG
      REAL ALPH(6), BETA(6), ATWO(4), BTWO(4), DUST(4,2)
      DATA ALPH / 5.70,4.00,0.757,-5.41,-15.29,-30.43/,
     1  BETA/ 0.620,0.842,1.107,1.459,1.898,2.449/,
     2  ATWO/ 1.18,2.20,0.95,0.35 /,
     3  BTWO /-0.77,-0.97,-0.75,-0.45/,
     4  DUST /0.06,0.06,0.05,0.07,0.08,0.10,0.07,0.09 /
      VPS(THA)=2.1718E8*EXP(-4157.0/(THA+239.09))
      IQUIT=0
C
C     CHECK ON ATMOSPHERIC PRESSURE
C
      IF (INDEX(1).GT.0) GO TO 110
      TEMP=1013.0*10.0**(-5.25E-5*RESEL)
      DO 100 J=NGO,NINT
      AP(J)=TEMP
100   CONTINUE
C
C     GENERAL INPUT DATA CHECKS
C
110   DO 120 J=2,4
      IF (INDEX(J).LE.0) IQUIT=1
120   CONTINUE
```

```
      IF (INDEX(5)+INDEX(6). LE. 0) IQUIT-1
      IF (IQUIT. LE. 0) GO TO 130
      WRITE (6,300)
      STOP
130   IF (INDEX(6)+INDEX(8). GT. 0) GO TO 150
C
C     WET BULB IS AVAILABLE
C
      DO 140 J=NGO,NINT
      EA(J)=VPS(WBT(J))-AP(J)*(DBT(J)-WBT(J))*(6. 6E-4+7. 59E-7*WBT(J))
      WC(J)=0. 86*(1. 26E-5*(DBT(J)+273. 0)**2)**8. 33
140   CONTINUE
      GO TO 180
C
C     DEW POINT AVAILABLE
C
150   DO 170 J=NGO,NINT
      IF (INDEX(8). EQ. 0) GO TO 160
      EA(J)=RELHUM(J)*VPS(DBT(J))
      DPT(J)=-4157. 0/ALOG(4. 61E-9*EA(J))-239. 09
      WC(J)=0. 86*EXP(0. 111+0. 0614*DPT(J))
      GO TO 170
160   EA(J)=VPS(DPT(J))
      WC(J)=0. 86*EXP(0. 111+0. 0614*DPT(J))
170   CONTINUE
C
C     SOLAR RADIATION CALCULATIONS
C     CALCULATE SOME CONSTANTS
C
180   NHRS=24/NOBS
      HRS=FLOAT(NHRS)
      SRO=SRO/57. 3
      SSO=SSO/57. 3
      CONE=3. 14159*LAT/180. 0
      TC=FLOAT((IFIX(LOG)/15)*15)
      TC=(LOG-TC)/15. 0
C
C     ENTER MAIN CALCULATION LOOP
C
      LL=0
      DO 220 L=IDAY,LDAY
      LL=LL+1
      KK=L/92+1
C
C     SET UP DAILY VALUES
C
      R=1. 0+0. 017*COS(1. 72E-2*FLOAT(181-L))
      DEL=0. 409*COS(1. 72E-2*FLOAT(172-L))
      CTWO=SIN(CONE)*SIN(DEL)
      CTRI=COS(CONE)*COS(DEL)
      HSR=-3. 82*ACOS((SIN(SRO)-CTWO)/CTRI)+TC
      HSS=3. 82*ACOS((SIN(SSO)-CTWO)/CTRI)+TC
      TIME=-12.0
      QONE=0.0
      RONE=0.0
      NN=NOBS*(LL-1)
C
C     ENTER INTERVAL LOOP
C
      DO 210 K=1,NOBS
      SUMQ=0.0
      RSUM=0.0
      N=NN+K
      M=1
      IF (CLD(N).LT.0.1) GO TO 190
      M=2+INT((CLD(N)-0.101)/0.40)
190   CS=1.0-0.65*CLD(N)**2
C
C     ENTER HOUR LOOP
C
      DO 200 J=1,NHRS
      TIME=TIME+1.0
      IF (TIME.LE.HSR.OR.TIME.GE.HSS) GO TO 200
      AL=ASIN(SIN(CONE)*SIN(DEL)+COS(CONE)*COS(DEL)*COS(0.262*TIME))
      IF (AL.LE.0.0.OR.AL.GE.1.57) GO TO 200
      TEMP=AP(N)/1013.0
      CM=TEMP/(SIN(AL)+0.15*(57.3*AL+3.885)**(-1.253))
      TEMP=0.17*EXP(-0.88*CM)+0.129
      AI=EXP(-(0.465+0.134*WC(N))*TEMP*CM)
      TEMP=0.421*EXP(-0.721*CM)+0.179
      AII=EXP(-(0.465+0.134+WC(N))*TEMP*CM)
      QO=0.33*SIN(AL)/R**2
      RSO=ATWO(1)*(57.3*AL)**BTWO(1)
      RFO=ATWO(M)*(57.3*AL)**BTWO(M)
      IF (RFO.GT.1.0) RFO=1.00
      MM=1
      IF (CM.GT.1.5) MM=2
      TEMP=AII+0.5*(1.0-AI-DUST(KK,MM))
      TEMP=TEMP/(1.0-0.5*RSO*(1.0-AI+DUST(KK,MM)))
      QTWO=QO*TEMP*CS
      SUMQ=SUMQ+0.5*(QONE+QTWO)
      RTWO=QTWO*(1.0-RFO)
      RSUM=RSUM+0.5*(RONE+RTWO)
      QONE=QTWO
      RONE=RTWO
200   CONTINUE
      RTEMP=RSUM/SUMQ
      IF (INDEX(7).LE.0) QS(N)=SUMQ/HRS
      QNS(N)=RTEMP*QS(N)
210   CONTINUE
220   CONTINUE
C
C     NET ATMOSPHERIC
C
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```
      DO 230 J=NGO,NINT
      QAT(J)=1. 233E-16*(1. 0+0. 17*CLD(J)**2)*(DBT(J)+273. 0)**6
230   CONTINUE
C
C     CALCULATE EQUILIBRIUM TEMPERATURES
C
      DO 250 J=NGO,NINT
      NTMP=DBT(J)
      PTEMP=NTMP
      DO 240 JJ=1,5
      XTEMP(JJ)=PTEMP+JJ-3. 0
      ESAT=VPS(XTEMP(JJ))
      RHO=1000. 0-(((XTEMP(JJ)-3. 98)**2*(XTEMP(JJ)+283. 0))/(503. 57*(XTEMP
     1(JJ)+67. 26)))
      HV=597. 0-0. 57*(ESAT-EA(J))
      EV=(A+WS(J)*B)*(ESAT-EA(J))
      QE=RHO*HV*EV
      RATIO=0. 61E-3*(XTEMP(JJ)-DBT(J))*AP(J)/(ESAT-EA(J))
      QC=QE*RATIO
      QW=7. 36E-2+1. 17E-3*XTEMP(JJ)
      QNET(JJ)=QNS(J)+QAT(J)-QW-QC-QE
240   CONTINUE
      CALL SLOPE (XTEMP,QNET,AA,BB,5)
      BB=-BB
      AA=AA/BB
      IF (AA.LT.0.0) AA=0.0
      ET(J)=AA
      XK(J)=BB
250   CONTINUE
C
C     WRITE OUTPUTS
C
      DO 260 K=NGO,NINT,30
      MAX=K+29
      IF (MAX.GT.NINT) MAX=NINT
      WRITE (6,280)
C
C        QNS - NET SHORT WAVE SOLAR RADIATION (KCAL/M.**2*SEC)
C        QAT - LONG WAVEATMOSPHERIC RADIATION (KCAL/M.**2*SEC)
C        AP  - ATMOSPHERIC PRESSURE (MB)
C        DBT - DRY BULB TEMPERATURE ( C)
C        EA  - ATMOSPHERIC VAPOR PRESSURE (MB)
C        WS  - WIND SPEED (M./SEC)
C        ET  - EQUILIBRIUM TEMPERATURE ( C)
C        CLD - CLOUDINESS (#)
C        DPT - DEW POINT TEMPERATURE ( C)
C        QS  - GROSS SHORT WAVE SOLAR RADIATION
C        WBT - WET BULB TEMPERATURE ( C)
C        WC  - WATER CONTENT OF THE ATMOSPHERE
C
      WRITE (6,290) (J,QNS(J),QAT(J),AP(J),DBT(J),EA(J),WS(J),ET(J),XK(J
     1),J=K,MAX)
```

```
260   CONTINUE
      IF (ITAPE LE 0) RETURN
      WRITE (4) IYR,IDAY,LDAY,NOBS
      DO 270 J-NGO,NIN
      WRITE (4) QNS(J),QAT(J),AP(J),DBT(J),EA(J),WS(J)
270   CONTINUE
      END FILE 4
      RETURN
C
C
280   FORMAT (1H1,//,48X,'RESERVOIR SIMULATION PROGRAM'/53X,'BATTELLE-NO
     1RTHWEST'/46X,'WATER RESOURCES SYSTEMS SECTION'/45X,'P.O. BOX 999,
     2RICHLAND WASHINGTON'//50X,28(1H*)/50X,'*  THERMAL INPUT ANALYSIS
     3*'/50X,28(1H*)//)
290   FORMAT (3X,93HNO     NET SOLAR    NET ATMOS     AT PRESS     DRY BL
     1UB        AV PRESS     W. SPEED    EQ TEMP/7X,'(KCAL/M2-SEC) (KCAL/
     2M2-SEC)     (MB)          (C)               (MB)      (M/SEC)       (
     3C)'/139(1H-)/I5,1P8E13.3)
300   FORMAT (//20X,37HSOME NECESSARY PARAMETERS ARE MISSING//22X 17H**
     1PROGRAM HALTED)
      END
      SUBROUTINE SUBC
C
C     THIS SUBROUTINE PREPARES THREE SETS OF HYDRUALIC DATA FOR TSIP.
C     THE DATA PREPARED IS:
C                           1.  UPSTREAM INFLOW FILE
C                           2.  OUTFLOW FILE
C                           3.  TRIBUTARY INFLOW FILE
C     AND ARE WRITTEN OUT TO UNIT 4.
C
      PARAMETER III=365,JJJ=5
      DIMENSION ELOUT(JJJ),WOT(JJJ),QOT(III,JJJ)
      DIMENSION QIN(III),  TIN(III)
      DIMENSION TA(III),TB(III),TC(III)
      EQUIVALENCE (TA,QOT),(TB,TIN),(TC,QIN)
C
C        INPUT - GROUP II
C
C        CARD 1
C     IDAY..........FIRST JULIAN DAY FOR THE DATA FILE
C     LDAY..........LAST  JULIAN DAY FOR THE DATA FILE
C     A1,B1,C1,C2...UNITS CONVERSION CONSTANTS
C        (3I5,4E10.0)
C                 1.  WRITE THE UPSTREAM INFLOW FILE.
      WRITE (6,190)
      READ (2,330) IDAY,LDAY,IDUMMY,A1,B1,C1,C2
      WRITE (6,200) IDAY,LDAY
      IF (IDAY.LE.0.OR.LDAY.LT.IDAY) STOP
      IF (A1.LE.0.0) A1=1.0
      IF (B1.LE.0.0) B1=1.0
      IF (C1.LE.0.0) C1=1.0
      WRITE (4) IDAY,LDAY
C
C        CARD 2
C     TA............AVERAGE DAILY WATER SURFACE ELEVATION (M.)
C     TB............AVERAGE DAILY INFLOWS (M.**3/SEC)
C     TC............AVERAGE DAILY INFLOWS TEMPERATURES ( C)
C        (8E10.0)
      N=LDAY-IDAY+1
      DO 100 II=IDAY,LDAY
      READ (2,210) TA(II),TB(II),TC(II)
C     UNITS CONVERSIONS--> FT-M,  CFS-CMS,  F-C
      TA(II)=A1*TA(II)
      TB(II)=B1*TB(II)
      TC(II)=C1*(TC(II)+C2)
  100 WRITE (4) TA(II),TB(II),TC(II)
      END FILE 4
      WRITE (6,240)
      WRITE (6,250)
      CALL PICTUR (N,TA)
      WRITE (6,240)
      WRITE (6,260)
      CALL PICTUR (N,TB)
      WRITE (6,240)
      WRITE (6,270)
      CALL PICTUR (N,TC)
C                 2.  WRITE THE OUTFLOW FILE
C
C        CARD 3
C     NOUTS.........NUMBER OF OUTFLOWS(DISCRETE WITHDRAWALS)
C        (3I5, 3E10.0)
      READ (2,330) IDAY,LDAY,NOUTS,A1,B1,C1
      IF (A1.LE.0.0) A1=1.0
      IF (B1.LE.0.0) B1=1.0
      IF (C1.LE.0.0) C1=1.0
      WRITE (6,220)
      WRITE (6,230) IDAY,LDAY,NOUTS
      IF (IDAY.LE.0.OR.NOUTS.LE.0.OR.LDAY.LT.IDAY) STOP
C
C        CARD 4
C     ELOUT.........CORRESPONDING ELEVATION OF THE OUTFLOW (M.)
C     WOT...........CORRESPONDING DAM WIDTHAT ELEVATION OF OUTLET (M.)
C        (8E10.0)
      N=LDAY-IDAY+1
      DO 110 JJ=1,NOUTS
      READ (2,210) ELOUT(JJ),WOT(JJ)
      ELOUT(JJ)=A1*ELOUT(JJ)
110   WOT(JJ)=B1*WOT(JJ)
      WRITE (4) IDAY,LDAY,NOUTS,(ELOUT(I),WOT(I),I=1,NOUTS)
C
C        CARD 5
C     QOT...........AVERAGE DAILY OUT FLOW (M.**3/SEC.)
C        (8E10.0)
      DO 120 I=1,NOUTS
120   READ (2,210) (QOT(IJK,I),IJK=1,N)
      DO 140 IJK=1,N
      DO 130 I=1,NOUTS
130   QOT(IJK,I)=C1*QOT(IJK,I)
140   WRITE (4) (QOT(IJK,I),I=1,NOUTS)
      END FILE 4
      DO 150 J=1,NOUTS
      WRITE (6,280)
      WRITE (6,290) J
      DO 145 I=1,N
145   QIN(I)=QOT(I,J)
150   CALL PICTUR (N,QIN)
C                 3.  WRITE THE TRIBUTARY INFLOW FILE
C
C        CARD 6
C     NTRIB.........NUMBER OF TRIBUTARIES
C        (3I5, 3E10.0)
      READ (2,330) IDAY,LDAY,NTRIB,A1,B1,B2
      IF (A1.LE.0.0) A1=1.0
      IF (B1.LE.0.0) B1=1.0
      IF (IDAY.LE.0.OR.LDAY.LT.IDAY) STOP
      WRITE (4) IDAY,LDAY
      IF (NTRIB.LE.0) GO TO 180
C
C        CARD 7
C     QIN...........TRIBUTARY INFLOW RATE (M.**3/SEC)
C     TIN...........TRIBUTARY INFLOW TEMPERATURE ( C)
C        (8E10.0)
      N=LDAY-IDAY+1
      DO 170 KK=1,NTRIB
      DO 160 JI=1,N
      READ (2,210) QIN(JI),TIN(JI)
      QIN(JI)=A1*QIN(JI)
160   TIN(JI)=B1*(TIN(JI)+B2)
      WRITE (4) (QIN(I),TIN(I),I=1,N)
      WRITE (6,300)
      WRITE (6,310)
      CALL PICTUR (N,QIN)
      WRITE (6,300)
      WRITE (6,320)
      CALL PICTUR (N,TIN)
170   CONTINUE
180   END FILE 4
      RETURN
C
190    FORMAT (1H1,//,30X,'RESERVOIR SIMULATION PROGRAM'/35X,'BATTELLE-NO
     1RTHWEST'/28X,'WATER RESOURCES SYSTEMS SECTION'/27X,'P.O.  BOX 999,
     2RICHLAND WASHINGTON'//28X,30(1H*)/28X,'*  HYDRAULIC INPUT ANALYSIS
     3  *'/28X,30(1H*)//)
200    FORMAT (1H0,38X,'FIRST LAST'/40X,9HDAY   DAY/38X,12(1H-)/38X,12I5)
210    FORMAT (8E10.2)
220    FORMAT (1H1,56X,'NUMBER OF OUTFLOWS')
230    FORMAT (1H0,57X,'FIRST LAST OUT-'/59X,'DAY   DAY FLOWS'/57X,20(1H-
     1)/57X,6I5//)
240    FORMAT (1H1,52X,'UPSTREAM INFLOW FILE')
250    FORMAT (42X,'AVERAGE DAILY WATER SURFACE ELEVATION (M.)'//)
260    FORMAT (46X,'AVERAGE DAILY INFLOWS (M.**3/SEC)'//)
270    FORMAT (44X,'AVERAGE DAILY INFLOW TEMPERATURES (C)'//)
280    FORMAT (1H0,56X,'OUTFLOW FILE')
290    FORMAT (46X,'OUTLET NO.',I5,/46X,'AVERAGE DAILY OUTFLOW (M.**3/SEC
     1)',/)
300    FORMAT (1H1,52X,'TRIBUTARY INFLOW FILE')
310    FORMAT (46X,'TRIBUTARY INFLOW RATE (M.**3/SEC)'//)
320    FORMAT (46X,'TRIBUTARY INFLOW TEMPERATURE (C)'//)
330    FORMAT (3I5,5E10.0)
       END
      SUBROUTINE SLOPC (Z,SIGMA,A,B,NPOINT)
C
C     THIS SUBROUTINE PERFORMS A LEAST-SQUARES LINEAR FIT ON 5 POINTS.
C     THE INDEPENDENT VARIABLE IS TEMPERATURE AND THE DEPENDENT IS QNET.
C     THE ROUTINE RETURNS THE SLOPE B AND INTERCEPT A.
C
      DIMENSION Z(5), SIGMA(5)
      ZBAR-0.0
      ZBAR2=0.0
      SIGMAB=0.0
      SIBZ=0.0
      DO 100 N=1,NPOINT
      ZBAR=Z(N)+ZBAR
      ZBAR2=Z(N)**2+ZBAR2
      SIGMAB-SIGMA(N)+SIGMAB
      SIGZ=SIGMA(N)*Z(N)+SIGZ
100   CONTINUE
      XPOINT=NPOINT
      ZBAR=ZBAR/XPOINT
      ZBAR2=ZBAR2/XPOINT
      SIGMAD=SIGMAB/XPOINT
      SIGZ=SIGZ/XPOINT
      B=((SIGMAB*ZBAR)-SIGZ)/((ZBAR**2)-ZBAR2)
      A=SIGMAB-B*ZBAR
      RETURN
      END
      SUBROUTINE PICTUR (N,YY)
C
C     PRESENTS A PICTURE OF DATA ON PRINTED OUTPUT, TWO OPTIONS BEING
C     AVAILABLE
C        1   MCOL POSITIVE
C        2   MCOL NEGATIVE, IN WHICH CASE XINCREMENTS ARE TAKEN AS EQUAL
C            TO Y INCREMENTS AS DETERMINED BY M
C
C     DICTIONARY
C
C        VARIABLE   DEFINITION
C          N        NUMBER OF POINTS TO PLOT     (MAXIMUM OF 500)
C          M        MAXIMUM NUMBER OF LINES
C          MCOL     MAXIMUM NUMBER OF COLUMNS
C
C         XX(I)     X COORDINATE FOR ITH POINT
C         YY(I)     Y COORDINATE FOR ITH POINT
C         ARK(I)    MARKER FOR ITH POINT
C         ISYM(I)   PRIORITY DESIGNATOR FOR MARKER USED ON I-TH POINT
C                         (LOWER SUBSCRIPT INDICATES HIGHER PRIORITY)
C
C
      PARAMETER NN=365
      EQUIVALENCE (IXYM,XYM)
      EQUIVALENCE (ILF,ALF),(BLANK,LANKBA)
      DIMENSION IXYM(3,NN), XYM(3,NN),ARK(NN),XX(NN),YY(N)
      DIMENSION PX(6),ALF(107),ILF(107),ISYM(NN)
C
      DATA BLANK/1H  /
      DATA SYMBOL/1H*/
C
      EXTERNAL SORDER
C
      M=25
      MCOL=95
      DO 100 I=1,N
      XX(I)=FLOAT(I)
      ARK(I)=SYMBOL
      ISYM(I)=SYMBOL
100   CONTINUE
      N=MAX0(MIN0(500,N),2)
      XYM(1,2)=1.01
      XYM(2,2)=1.01
      XYM(3,2)=BLANK
      XMIN=1.0E37
      XMAX=-1.0E37
      DO 110 I=1,N
      XYM(1,I)=XX(I)
      XYM(2,I)=YY(I)
      XYM(3,I)=ARK(I)
      XMIN=AMIN1(XMIN,XYM(1,I))
      XMAX=AMAX1(XMAX,XYM(1,I))
110   CONTINUE
      CALL SORT (XYM,N,3,SORDER)
      YMIN=XYM(2,N)
      YMAX=XYM(2,1)
      YTEST=(YMAX-YMIN)/FLOAT(M)*1.0E5
      IF (YTEST.LE.0.0) WRITE (6,510) YMAX
      IF (YTEST.LE.0.0) RETURN
      DYLOG=ALOG10(YTEST)
      APROX=DYLOG-AINT(DYLOG)
      DO 120 I=2,10
      FI=I
      IF (APROX-ALOG10(FI)) 130,130,120
120   CONTINUE
130   EXACT=FI*10.0**(INT(DYLOG)-5)
      IF (MCOL) 200,140,140
140   DXLOG=ALOG10((XMAX-XMIN)/FLOAT(MCOL/2)*1.0E5)
      XAPROX=DXLOG-AINT(DXLOG)
      IF (XAPROX-.3010) 150,150,160
150   XEXACT=2.0*10.0**(INT(DXLOG)-5)
      GO TO 190
160   IF (XAPROX-.6990) 170,170,180
170   XEXACT=5.0*10.0**(INT(DXLOG)-5)
      GO TO 190
180   XEXACT=10.0**(INT(DXLOG)-4)
190   CONTINUE
      XACT=XEXACT/2.0
      GO TO 210
200   XACT=EXACT/2.0
210   TENX=20.0*XACT
      TENE=10.0*EXACT
      MAXYI=(YMAX/TENE)+(0.5+SIGN(0.5,YMAX))
      MAXXI=(XMAX/TENX)+(0.5+SIGN(0.5,XMAX))
      MINYI=(YMIN/TENE)-(0.5+SIGN(0.5,-YMIN))
      MINXI=(XMIN/TENX)-(0.5+SIGN(0.5,-XMIN))
      YFIRST=TENE*FLOAT(MAXYI)
      XFIRST=TENX*FLOAT(MINXI)
      LINES=10*(MAXYI-MINYI)+1
      KOLS=20*(MAXXI-MINXI)
      IF (KOLS-500) 230,230,220
220   WRITE (6,480) KOLS
      KOLS=500
230   IF (LINES-401) 250,250,240
240   WRITE (6,490)
      RETURN
250   CONTINUE
      LEAF=(KOLS+99)/100
      DO 430 L=1,LEAF
      DO 260 I=1,6
      PX(I)=5.*TENX*FLOAT(L-1)+TENX*FLOAT(I-1)+XFIRST
260   CONTINUE
      WRITE (6,470) PX
      WRITE (6,460)
      DEX=XACT/2.0
      DEL=EXACT/2.0
      DDD=DEX+2.0*XACT
      J=1
      DO 420 I=1,LINES
      YPLOT=YFIRST-EXACT*FLOAT(I-1)
      DO 270 JKL=1,107
270   ALF(JKL)=BLANK
280   IF (J-N) 290,290,380
290   IF (XYM(1,J)-PX(1)) 370,300,300
300   CONTINUE
      IF (XYM(2,J)-(YPLOT+DEL)) 310,310,380
310   IF (XYM(2,J)-(YPLOT-DEL)) 380,380,320
320   CONTINUE
      IF (XYM(1,J)-PX(6)-DDD) 330,330,370
330   CONTINUE
      KOL=INT((XYM(1,J)+DEX-PX(1))/XACT)+4
      IF ((KOL.GT.107).OR.(KOL.LT.1)) GO TO 370
      IXYM3J=IXYM(3,J)
      ILFKOL=ILF(KOL)
      IF (ILFKOL.EQ.LANKBA) GO TO 360
      ISYM1=0
      ISYM2=0
      DO 340 IIYY=1,5
      IF (ILFKOL.EQ.ISYM(IIYY)) ISYM1=IIYY
      IF (IXYM3J.EQ.ISYM(IIYY)) ISYM2=IIYY
340   CONTINUE
      ISYMM=MIN0(ISYM1,ISYM2)
      IF (ISYMM) 370,370,350
350   ILF(KOL)=ISYM(ISYMM)
      GO TO 370
360   ALF(KOL)=XYM(3,J)
370   J=J+1
      GO TO 280
380   CONTINUE
      IF (MOD(I-1,10).NE.0) GO TO 390
      WRITE (6,440) YPLOT,ALF
      GO TO 410
390   IF (MOD(I-1,5).NE.0) GO TO 400
      WRITE (6,500) ALF
      GO TO 410
400   WRITE (6,450) ALF
410   CONTINUE
420   CONTINUE
      WRITE (6,460)
      WRITE (6,470) PX
430   CONTINUE
      RETURN
C
440   FORMAT (1XF9.3,2H *107A1,1H*)
450   FORMAT (11X1HI107A1,1HI)
```

```
460   FORMAT (1H014X1H*5(20H - - - - + - - - - - *)/1H )
470   FORMAT (11XF7.2,5(13XF7.2))
480   FORMAT (48H0ONLY THE FIRST 500 COLUMNS OF A PLOT REQUIRING I3,25H
     1COLUMNS WILL BE PRINTED.)
490   FORMAT (69H0NOBODY IN THEIR RIGHT MIND WOULD WANT A PLOT OF MORE T
     1HAN 400 LINES.)
500   FORMAT (11X1H+107A1,1H+)
510   FORMAT (1H0,37X,'CONSTANT VALUES = ',F12.5,10X,'**NO PLOT**')
      END
      SUBROUTINE SORT (M,N,ITEM,Q)
C
C     GENERAL PURPOSE INTERNAL SORT SUBROUTINE
C
C     EXAMPLE OF USE - - -    ASSUME -    N ITEMS OF 5 WORDS EACH
C                                         TO BE SORTED IN ASCENDING
C                                         ORDER ON THE SECOND WORD.
C     MAIN PROGRAM
C     DIMENSION A(5,1000)     N IS LESS THAN OR EQUAL TO 1000
C                             A CONTAINS THE ITEMS TO BE SORTED
C
C     EXTERNAL Q          Q IS A FUNCTION SUBROUTINE WHICH WILL RETURN
C     .                   A POSITIVE NUMBER IF THE FIRST ITEM (FIRST
C     .                   ARGUMENT) IS TO SORT AHEAD OF THE  SECOND
C     .                   ITEM (SECOND ARGUMENT).    SEE EXAMPLE BELOW
C
C     CALL SORT (A,N,5,Q)     ARGUMENT    MEANING
C     .                        FIRST      ARRAY CONTAINING ITEMS
C     .                        SECOND     NUMBER OF ITEMS
C     .                        THIRD      NUMBER OF WORDS PER ITEM
C     .                        FOURTH     FUNCTION SUBROUTINE TO
C     .                                          DEFINE SORT ORDER
C
C     FUNCTION Q(B,C)           WRITE A FUNCTION SUBROUTINE SUCH AS THIS.
C     DIMENSION B(5),C(5)       IT SHOULD RETURN A POSITIVE RESULT IF
C     Q=C(2)-B(2)               THE FIRST ARGUMENT SHOULD SORT AHEAD
C     RETURN                    OF THE SECOND ARGUMENT.   THIS ROUTINE
C     END                       PRODUCES AN ASCENDING SORT ON THE SECOND
C                               WORD  OF THE ITEMS.
C
C     NOTE - -  THE MAXIMUM NUMBER OF WORDS PER ITEM IS LIMITED
C     BY THE DIMENSION OF KOPY.      THIS LIMIT IS PRESENTLY 100.
C
C     APPROXIMATE SPEED IS 250 ITEMS PER SECOND.
      INTEGER W
      PARAMETER NN=365
      DIMENSION KOPY (100)
      DIMENSION M(ITEM,NN)
      IF (N-1) 320,320,100
100   K=N/2+1
      L=N/2-1
      IF (L) 210,210,110
110   CONTINUE
      DO 200 II=1,L
      I=K-II
      IS=I
      NS=N
      DO 120 IQ=1,ITEM
120   KOPY(IQ)=M(IQ,IS)
130   J=2*IS
      IF (J.GT.NS) GO TO 180
      IF (J.GF.NS) GO TO 150
      IF (Q(M(1,J+1),M(1,J))) 140,150,150
140   J=J+1
150   IF (Q(M(1,J),KOPY)) 160,180,180
160   DO 170 IQ=1,ITEM
170   M(IQ,IS)=M(IQ,J)
      IS=J
      GO TO 130
180   DO 190 IQ=1,ITEM
190   M(IQ,IS)=KOPY(IQ)
200   CONTINUE
210   NPLUS=N+2
      DO 310 II=2,N
      I=NPLUS-II
      IS=1
      NS=I
      DO 220 IQ=1,ITEM
220   KOPY(IQ)=M(IQ,IS)
230   J=2*IS
      IF (J.GT.NS) GO TO 280
      IF (J.GE.NS) GO TO 250
      IF (Q(M(1,J+1),M(1,J))) 240,250,250
240   J=J+1
250   IF (Q(M(1,J),KOPY)) 260,280,280
260   DO 270 IQ=1,ITEM
270   M(IQ,IS)=M(IQ,J)
      IS=J
      GO TO 230
280   DO 290 IQ=1,ITEM
290   M(IQ,IS)=KOPY(IQ)
      DO 300 IT=1,ITEM
      LAZY=M(IT,1)
      M(IT,1)=M(IT,I)
      M(IT,I)=LAZY
300   CONTINUE
310   CONTINUE
320   CONTINUE
      RETURN
      END
      FUNCTION SORDER(FIRST,SECOND)
C
      DIMENSION FIRST(3),SECOND(3)
      SORDER=FIRST(2)-SECOND(2)
      RETURN
      END
```

```
      FUNCTION Q(B,C)
C
      DIMENSION B(2),C(2)
      Q=C(2)-B(2)
      RETURN
      END
```

FIGURE C-36. PROGRAM LISTING FOR TERMA

```
C        TERMA:
C     THERMAL RESERVOIR SIMULATION PROGRAM
C
C     ORIGINALLY PROGRAMMED BY WATER RESOURCES ENGINEERS
C     MODIFIED AND REVISED BY ROBT. BACA-JANUARY 1972
C     WATER RESOURCES SYSTEMS SECTION, BATTELLE-NORTHWEST
C     P.O. BOX 999,  RICHLAND, WASHINGTON 99352
C
C        GENERAL:
C     TERMA SIMULATES THE THERMAL BEHAVIOR OF A RESERVOIR SYSTEM BY THE
C     SUCCESSIVE SIMULATION OF SPECIFIED NUMBER OF RESERVOIR SEGMENTS;
C     EACH SEGMENT IS COMPOSED OF N HORIZONTAL ELEMENTS  A SIMULATION
C     SCHEME IS PROGRAMMED TO SIMULATE THE ENTIRE SYSTEM, SEGMENT BY
C     SEGMENT, WORKING DOWNSTREAM.  USING THIS PROCEDURE A QUASI TWO-
C     DIMENSIONAL REPRESENTATION OF THE RESERVOIR IS OBTAINED FROM A
C     SERIES OF ONE-DIMENSIONAL SOLUTIONS.
C
C        DATA   DETAIL:
C     ONE SET OF METEOROLOGIC/HYDROLOGIC/HYDRAULIC DATA IS REQUIRED TO
C     CHARACTERIZE A RESERVOIR SITE.  THIS PROGRAM WILL SIMULATE ANY
C     NUMBER OF RESERVOIR SEGMENTS AND UP TO 200 ELEMENTS PER SEGMENT.
C     THE PROGRAM IS CODED TO OPERATE FOR UP TO 365 CONSECUTIVE DAYS,
C     WITH UP TO 24 TIME PERIODS PER DAY.  THIS VERSION WILL ALLOW UP TO
C     10 SEPARATE RESERVOIR WITHDRAWLS, AND UP TO 5 SEPARATE INTERFLOWS.
C     NO MORE THAN 1 TRIBUTARY INFLOW IS ALLOWED TO ANY SEGMENT, AND
C     CORRECT SEQUENCING OF THERMAL INPUT FILE FOR SEGMENT SIMULATION IS
C     LEFT TO THE USER.
C
C        ASSUMPTIONS:
C     IN THE MODEL'S FORMULATION AND SOLUTION THE FOLLOWING ASSUMPTIONS
C     ARE MADE CONCERNING THE PROPERTIES OF ELEMENTS AND THE TRANSFER OF
C     THERMAL ENERGY BETWEEN ADJACENT ELEMENTS, AND ELEMENTS AND THEIR
C     BOUNDARIES:
C
C        1.   A RESERVOIR ELEMENT IS HOMOGENEOUS AND ISOTROPIC IN ITS
C             PHYSICAL PROPERTIES.  EACH ELEMENT BEING DEFINED BY THE
C             SCALAR PROPERTIES AT ITS VERTICAL MIDPOINT.
C        2.   WITHIN THE BODY OF THE RESERVOIR, ALL HEAT TRANSFER OCCURS
C             AS SOME COMBINATION OF FOUR  PROCESSES:
C                  (A) SHORT WAVE SOLAR ENERGY ADSORPTION
C                  (B) EDDY DIFFUSION
C                  (C) HORIZONTAL ADVECTION
C                  (D) VERTICAL ADVECTION.
C             (THE NET RATE OF HEAT TRANSFER TO EACH ELEMENT EQUALS THE
C              SUM OF THE RATES AT WHICH EACH PROCESS TRANSFERS ENERGY
C              ACROSS THE ELEMENT. )
C        3.   THE RESERVOIR SIDES AND BOTTOM ARE ADIABATIC: NO HEAT CROSS
C             -ES ANY SOIL-WATER INTERFACE.
C        4.   THE HEAT TRANSFER AT THE AIR-WATER INTERFACE IS DEFINED
C             FROM THE PROPER FORMULATION OF FIVE CONSTITUENTS:
C                  (A) SHORT WAVE SOLAR RADIATION
```

```
C                 (B) LONG WAVE ATMOSPHERIC RADIATION
C                 (C) LONG WAVE BACK RADIATION
C                 (D) HEAT TRANSFER BY CONDUCTION
C                 (E) HEAT TRANSFER BY EVAPORATION
C
      PARAMETER NGROUP=2
      DIMENSION ITAB(45), CARDS(16)
      DATA TEST/5HEND  /
C
C     UNITS  1,2,9,10 ARE ASSIGNED AS TEMPORARY UNITS ON DRUM.
C     1,2 - SCRATCH FILES FOR UPSTREAM AND DOWNSTREAM FLOW DATA
C     9   - SCRATCH FILES ON WHICH THE METEOROLOGIC DATA IS TRANSFERRED
C     10  - SCRATCH FILES ON WHICH THE OUTFLOW FILE IS TRANSFERRED.
C     UNITS 11 AND 12 ARE USED TO STORE READ IN DATA
C
      CALL SETDR (1,300000,100000,ITAB(1))
      CALL SETDR (2,400000,100000,ITAB(8))
      CALL SETDR (9,500000,100000,ITAB(15))
      CALL SETDR (10,600000,100000,ITAB(22))
      CALL SETDR (11,700000,100000,ITAB(29))
      CALL SETDR (12,800000,100000,ITAB(36))
      REWIND 4
      REWIND 1
      REWIND 2
      REWIND 9
      RCWIND 10
      REWIND 11
      REWIND 12
C
C           WRITE INPUT CARD IMAGES TO DRUM AND PRINTER
C
      WRITE (6,140)
      WRITE (6,150)
      DO 110 I=11,12
      L=1
100   READ (5,160,END=130) (CARDS(J),J=1,16)
      WRITE (6,170) L,(CARDS(J),J=1,16)
      IF (CARDS(1).EQ.TEST) GO TO 110
      WRITE (I,160) (CARDS(J),J=1,16)
      L=L+1
      GO TO 100
110   CONTINUE
      REWIND 11
      REWIND 12
      CALL SUBB
120   CALL AGAIN
      CALL SUBC
      GO TO 120
130   STOP
C
140   FORMAT (1H1,//,15X,'RESERVOIR SIMULATION PROGRAM',/,20X,'BATTELLE-
     1NORTHWEST',/,13X,'WATER RESOURCES SYSTEMS SECTION',/,12X,'P.O. BOX
     2 999, RICHLAND WASHINGTON',///,18X,'INPUT DATA CARD IMAGES'//)
 150  FORMAT (7X,80H12345678901234567890123456789012345678901234567890123456789012
     134567890123456789012345678 90//)
 160  FORMAT (16A5)
 170  FORMAT (I5,2X,16A5)
      END
      SUBROUTINE SUBB
C
C     SUBROUTINE SUBB PERFORMS MOST INITIALIZATION, FILE HANDLING, CARD
C     INPUT, AND PRINTED OUTPUT OPERATIONS FOR TSIP.  IN ADDITION THIS
C     SUBROUTINE GENERATES THE INITIAL CONDITIONS AND PHYSICAL DESCRIP-
C     TION FOR EACH RESERVOIR SEGMENT:  AREA VS ELEVATION, INITIAL AND
C     RATE OF TEMPERATURE CHANGE PROFILES.
C
      COMMON/ABLK/ ABAR(200), AREA(200), DC(200), DENS(200), DHI(200),
     1  DVOL(200), DZ(200), DZI(200), QHI(200), QHO(200), T(200),
     2  TDOT(200), TFX(200), THI(200), VOL(200), Z(200), ZMID(200)
      COMMON/BBLK/ A, AT, BB, EV, NAVG, QC, QE, QN, QNA, QNS, QH, WS
      COMMON/CBLK/ DST(365), POOL(365), UIN(365), RESTM(365), TIN(365)
      COMMON/DBLK/ DRODZ(10), ELOUT(10), NOU(10), OOT(10), TOUT(10),
     1  WOT(10)
      COMMON/EBLK/ IDOUT(50), ITRIB(6)
      COMMON/FBLK/ EUP(5), QUP(5), TUP(5),WUP(5)
      COMMON/NDV/ A1, A2, A3, DELT, DQIN, DTBY2, DZT, EDMAX, ELTC, EVA,
     1  EVAP, EXCO, GMAX, GMIN, GSWH, IAT, IBT, IDAY, IMIX, INTF, IONE,
     2  IPRT, ITAPE, ITWO, IVAL, LDAY, MAXE, MAXP, NLETS, NOBS, NOUTS,
     3  NTC, NREP, NSD, NSEG, NUM, NUME, NUMP, NUSI, NTRIBS, NXLQ, QI,
     4  QOUT, RESEL, RLEN, SDZ, SHEAT, STABLE, VONE, VSUM, VTOP, NTAPE,
     5  DZTOP
C
      DIMENSION CMENT(32), DUMMY(6), TF(200), VH(200), VZ(200)
C     INITIALIZE SYSTEM CONSTANTS AND PARAMETERS
      NPAGE=1
      NSEG=0
      NUSI=1
      IONE=2
      ITWO=1
      DO 100 J=1,5
      EUP(J)=0.0
      QUP(J)=0.0
      TUP(J)=0.0
      WUP(J)=0.0
100   CONTINUE
C     READ AND WRITE SYSTEM CARD INPUT
C        GROUP 1 - INPUT
C
C       CARDS 1-2
C     CMENT.........TITLE OR COMMENT CARDS(2)
C        <16A5>
      READ (11,510) CMENT
      WRITE (6,550) NPAGE,NSEG,CMENT
C
C       CARD  3
C     IDAY..........INITIAL DAY IN THE SIMULATION PERIOD
C     LDAY..........FINAL DAY IN SIMULATION PERIOD
C        <8I10>
      READ (11,530) IDAY,LDAY
```

```
C
C          CARD  4
C        UDZ...........SEGMENT ELEMENT THICKNESS(M. )
C        ELRES.........INITIAL SYSTEM WATER SURFACE ELEVATION(M. )
C        ELMAX.........MAXIMUM SYSTEM WATER SURFACE ELEVATION(M. )
C           (8E10.0)
         READ (11,520) UDZ,ELRES,ELMAX
         WRITE (6,570) IDAY,LDAY,UDZ,ELRES,ELMAX
C
C          CARD  5
C        EDMAX.........DEPTH OF SHORT WAVE EXTINCTION(M. )
C        A.............EVAPORATION RATE COEFFICIENT 1(M./(SEC*MB.))
C        BB............EVAPORATION RATE COEFFICIENT 2 (MB.)
C        GMAX..........MAXIMUM THERMAL GRADIENT ALLOWED( C/M. )
C        GMIN..........MINIMUM THERMAL GRADIENT ALLOWED( C/M. )
C           (8E10.0)
         READ (11,520) EDMAX,A,BB,GMAX,GMIN
         EXCO=6.908/EDMAX
         WRITE (6,500) EXCO,EDMAX,A,BB,GMAX,GMIN
C
C          CARD  6
C        NTRIBS........TOTAL NUMBER OF TRIBUTARY INFLOWS
C        ITRIB.........A LIST OF SEGMENTS WITH TRIBUTARY INFLOWS
C        NLETS.........NUMBER OF THE SEGMENT WITH OUTFLOWS
C        NOUTS.........NUMBER OF RESERVOIR SYSTEM OUTLETS.
C           (8I10)
         READ (11,530) NTRIBS,(ITRIB(J),J=1,5),NLETS,NOUTS
         WRITE (6,560) (J,ITRIB(J),J=1,NTRIBS)
         WRITE (6,720) NLETS
         MAX=0
C
105      CONTINUE
         MAX=MAX+1
         GO TO (110,160,210,260), MAX
C
C        READ METOROLOGIC INPUT FILE
C
110      READ (4) IYR,IA,IB,NOBS
         IF (IA.LE.IDAY.AND.IB.GE.LDAY) GO TO 120
         WRITE (6,690) MAX,IA,IB
         STOP
C
C        TRANSFER M. I. F. TO LOGICAL UNIT 9
C
120      IF (IA.EQ.IDAY) GO TO 140
         IC=NOBS*(IDAY-IA)
         DO 130 J=1,IC
         READ (4) TA
130      CONTINUE
140      DO 150 J=IDAY,IB
         DO 150 K=1,NOBS
         READ (4) DUMMY
```

```
      WRITE (9) DUMMY
150   CONTINUE
      WRITE (6,680) MAX,IDAY,IB,IYR
      READ (4,END=105)
C
C     READ UPSTREAM INFLOW FILE
C
160   READ (4) IA,IB
      IF (IA.LE.IDAY.AND.IB.GE.LDAY) GO TO 170
      WRITE (6,690) MAX,IA,IB
      STOP
C
C     TRANSFER U. I. F. TO LOGICAL UNIT 1
C
170   IF (IA.EQ.IDAY) GO TO 190
      IC=IDAY-IA
      DO 180 J=1,IC
      READ (4) TA
180   CONTINUE
190   WRITE (1) NOBS
      DO 200 J=IDAY,IB
      READ (4) POOL(J),QUP(1),TUP(1)
      EUP(1)=TUP(1)
      WUP(1)=TUP(1)
      DO 200 L=1,NOBS
      WRITE (1) QUP,TUP,WUP,EUP
200   CONTINUE
      WRITE (6,680) MAX,IDAY,IB,IYR
      READ (4,END=105)
C
C     READ THE OUTFLOW FILE
C
210   READ (4) IA,IB,NOUTS,(ELOUT(J),WOT(J),J=1,NOUTS)
      IF (IA.LE.IDAY.AND.IB.GE.IDAY) GO TO 220
      WRITE (6,690) MAX,IA,IB
      STOP
C
C     TRANSFER THE O. F. TO LOGICAL UNIT 10
C
220   IF (IA.EQ.IDAY) GO TO 240
      IC=IDAY-IA
      DO 230 J=1,IC
      READ (4) TA
230   CONTINUE
240   DO 250 J=IDAY,IB
      READ (4) (QOT(K),K=1,NOUTS)
      WRITE (10) (QOT(K),K=1,NOUTS)
250   CONTINUE
      WRITE (6,680) MAX,IDAY,IB,IYR
      READ (4,END=105)
C
C     POSITION TRIBUTARY INFLOW FILE
```

```
C
260   READ (4) IAT, IBT
      IF (IAT.LE.IDAY.AND.IBT.GE.LDAY) GO TO 270
      WRITE (6,690) MAX, IAT, IBT
      STOP
270   WRITE (6,700) MAX
      RETURN
C
      ENTRY AGAIN
C
      NPAGE=NPAGE+1
      REWIND IONE
      REWIND ITWO
      REWIND 9
      REWIND 10
      IONE=2-MOD(IONE+1,2)
      ITWO=2-MOD(ITWO+1,2)
      RESEL=ELRES
C     READ AND WRITE SEGMENT RUN PARAMETERS
C        GROUP II - INPUT
C
C       CARD  1
C     NSEG.........SEGMENT NUMBER.
C     NAP..........NUMBER OF POINTS IN SEGMENT AREA PROFILE.
C     NTP..........NUMBER OF POINTS IN SEGMENT INITIAL TEMP. PROFILE
C     NSD..........NUMBER OF DAYS FOR WHICH PRINTED OUTPUT IS REQUESTED
C     IPRT.........PRINTING INTERVAL
C     INTP.........PRINTING INTERVAL FOR VERTICAL ELEMENTS
C     ITAPE........FLAG FOR OUTPUT TO TAPE (>0)
C     NTAPE........TAPE IDENTIFICATION NUMBER (LOGICAL UNIT NUMBER)
C        (8I10)
      READ (12,530,END=470) NSEG, NAP, NTP, NSD, IPRT, INTP, ITAPE, NTAPE
      IF (NTAPE.NE.0) REWIND NTAPE
C
C       CARD  2
C     NXEQ.........NUMBER OF EXECUTIONS PER SIMULATION DAY
C     IVAL.........THE SIMULATION INTERVAL IN A DAY WITH OUTPUT.
C        (8I10)
      READ (12,530) NXEQ, IVAL
      IF (NXEQ.LE.0) NXEQ=1
      IF (IVAL.LE.0) IVAL=1
      WRITE (6,550) NPAGE, NSEG, CMENT
      WRITE (6,590) NSEG, NAP, NTP, NSD, IPRT, INTP, ITAPE, NOBS, NXEQ, IVAL
C
C       CARD  3
C     GSWH.........CRITICAL STABILITY PARAMETER (DEFAULT: GSWH=1.E-6)
C     A1...........DIFFUSION COEFFICIENT 1 (HYPOLIMNION)
C     A2...........DIFFUSION COEFFICIENT 2 (EPILIMNION)
C     A3...........DIFFUSION COEFFICIENT 3 (EPILIMNION)
C     SDZ..........VERTICAL THICKNESS OF STANDARD ELEMENT
C     RLEN.........HORIZONTAL SEGMENT LENGTH (M.)
C        (8E10.0)
```

```
      READ (12,520) GSWH,A1,A2,A3,SDZ,RLEN
      IF ((GSWH.LE.0.0).OR.(GSWH.GE.1.0)) GSWH=1.E-6
      IF ((A1.LE.0.0).OR.(A1.GT.10.0)) A1=1.E-6
      IF ((A2.LE.0.0).OR.(A2.GT.10.0)) A2=1.E-4
      IF ((ABS(A3).GT.5.0)) A3=0.0
      IF (SDZ.LT.0.05) SDZ=UDZ
      WRITE (6,710) GSWH,A1,A2,A3,SDZ,RLEN
C     INITIALIZE SELECTED ARRAYS
      DO 280 J=1,200
      AREA(J)=0.0
      DVOL(J)=0.0
      T(J)=0.0
      TDOT(J)=0.0
      VOL(J)=0.0
      Z(J)=0.0
280   CONTINUE
C     GENERATE ELEVATION PROFILE
C
C       CARD  4
C     TA............ELEVATION AT WHICH AREA IS SPECIFIED (M.)
C     TB............HORIZONTAL SURFACE AREA (M.**2)
C     TA,TB - VALUES FOR THE BOTTOM ELEMENT OF THE SEGMENT.
C        (8E10.0)
      READ (12,520) TA,TB
      Z(1)=TA
      AREA(1)=TB
      TC=0.5*SDZ
      DO 290 J=2,200
      Z(J)=Z(J-1)+SDZ
      ZMID(J-1)=Z(J-1)+TC
      DZ(J-1)=SDZ
290   CONTINUE
C     FIND SEGMENT LIMITS
      DO 300 J=1,200
      IF (ZMID(J).LT.ELMAX) GO TO 300
      MAXP=J
      MAXE=MAXP-1
      GO TO 310
300   CONTINUE
C     INPUT SEGMENT AREA POINTS
310   IF (NAP.GT.1) GO TO 330
      DO 320 J=1,MAXP
      AREA(J)=TB
320   CONTINUE
      GO TO 360
C
C       CARD  4
C     TA............ELEVATION AT WHICH AREA IS SPECIFIED (M.)
C     TB............HORIZONTAL SURFACE AREA (M.**2)
C     TA, TB - VALUES FOR ELEMENTS N=2,NUMBER OF SPECIF. DATA POINTS.
C        (8E10.0)
330   DO 350 J=2,NAP
```

```
      READ (12,520) TA,TB
      DO 340 K=1,MAXP
      IF (TA.GT.ZMID(K)) GO TO 340
      AREA(K)=TB
      GO TO 350
340   CONTINUE
350   CONTINUE
      CALL SUBG (NAP,AREA,200)
C     INPUT TEMPERATURE INITIALIZATION DATA POINTS
360   IF (NTP.GT.1) GO TO 380
      READ (12,520) TA,TB,TC
      DO 370 J=1,MAXP
      T(J)=TB
      TDOT(J)=TC
370   CONTINUE
      GO TO 410
C
C       CARD  5
C     TA............FLEVATION AT WHICH TEMPERATURE IS SPECIFIED (M.)
C     TB............INITAL TEMPERATURE ( C)
C     TC............INITIAL RATE OF TEMPERATURE CHANGE ( C/SEC. )
C        (OE10.0)
380   DO 400 J=1,NTP
      READ (12,520) TA,TB,TC
      IF (TC.EQ.0) TC=1.0E-9
      DO 390 K=1,MAXP
      IF (TA.GT.ZMID(K)) GO TO 390
      T(K)=TB
      TDOT(K)=TC
      GO TO 400
390   CONTINUE
400   CONTINUE
      CALL SUBG (NTP,T,200)
      CALL SUBG (NTP,TDOT,200)
C     INPUT DAYS FOR SPECIAL PRINTED OUTPUT
C
C       CARD  6
C     IDOUT.........JULIAN DAY NUMBER WITH PRINTED OUTPUT(UP TO 50 DAYS)
C        (16I5)
410   IF (NSD.GT.0) READ (12,540) (IDOUT(J),J=1,NSD)
C
C     GENERATE VOLUME PROFILE
C
      VOL(1)=0.0
      DO 420 J=2,MAXP
      DVOL(J-1)=0.5*(AREA(J)+AREA(J-1))*SDZ
      VOL(J)=VOL(J-1)+DVOL(J-1)
420   CONTINUE
C
C     LOCATE OUTLETS IN THIS SEGMENT
C
      IF (NSEG.NE.NLETS) GO TO 450
      DO 440 J=1,NOUTS
      DO 430 K=1,MAXP
      IF (ELOUT(J).GT.ZMID(K)) GO TO 430
      NOU(J)=K
      GO TO 440
430   CONTINUE
440   CONTINUE
      WRITE (6,600) (J,NOU(J),ELOUT(J),WOT(J),J=1,NOUTS)
C
C     WRITE OUT SYSTEM INFORMATION NOW AVAILABLE
C
450   MAX=INTP*75
      DO 460 J=1,MAXP,MAX
      IGO=J+INTP-1
      IEND=IGO+MAX-1
      IF (IEND.GT.MAXP) IEND=MAXP
      NPAGE=NPAGE+1
      WRITE (6,550) NPAGE,NSEG,CMENT
      WRITE (6,610) (K,Z(K),DZ(K),AREA(K),VOL(K),DVOL(K),T(K),TDOT(K),K=
     1IGO,IEND,INTP)
460   CONTINUE
      RETURN
470   STOP
C
      ENTRY PRNT(M,MM)
C
C     CONVERT TO DEG F AND CALCULATE ADVECTION RATIOS
      QVIN=0.0
      DO 480 J=1,NUME
      TF(J)=1.8*TFX(J)+32.0
      TA=1.0/DVOL(J)
      IF (J.EQ.NUME) TA=1.0/VTOP
      QVOT=QHI(J)+QVIN-QHO(J)
      VH(J)=DELT*AMAX1(QHI(J),QHO(J))*TA
      VZ(J)=DELT*AMAX1(ABS(QVIN),ABS(QVOT))*TA
      QVIN=QVOT
480   CONTINUE
C     WRITE SIMULATION OUTPUT
      NPAGE=NPAGE+1
C        NPAGE - PAGE NUMBER
C        NSEG  - SEGMENT NUMBER
C        CMENT - COMMENTS
C        M     - SIMULATION DAY
C        MM    - EXECUTION INTERVAL
C        RESEL - RESERVOIR ELEVATION
C        AT    - AIR TEMPERATURE
C        DZT   - VERTICAL THICKNESS OF UPPERMOST ELEMENT (NUME)
C        TFX   - TEMPERATURE OF UPPERMOST ELEMENT
C        QI    - TOTAL UPSTREAM INFLOW TO SEGMENT
C        EVA   - RATE OF EVAPORATION
C        QOUT  - TOTAL DOWNSTREAM OUTFLOW FROM SEGMENT
C        EVAP  - CUMULATIVE EVAPORATION
```

```
C       ELTC  - ELEVATION OF THERMOCLINE
C       SHEAT - NET RATE OF SURFACE HEATING
C       DST   - DOWNSTREAM TEMPERATURE ON SIMULATION DAY M
C       Z     - ELEVATION AT PLANE IMIX
C       IMIX  - NUMBER OF ELEMENTS TO WHICH MIXING HAS REACHED
C       RESTM - AVERAGE RESIDENCE TIME
C       QIN   - TRIBUTARY INFLOW
      WRITE (6,550) NPAGE,NSEG,CMENT
      WRITE (6,650) M,MM
      WRITE (6,620) RESEL,AT,DZT,TFX(NUME),QI,EVA,QOUT,EVAP,ELTC,SHEAT,D
     1ST(M),Z(IMIX),RESTM(M),QIN(M)
C       QN    - NET RADIATION HEAT TRANSFER (QN=QNS+QNA-QW)
C       QNS   - NET SHORT WAVE SOLAR RADIATION
C       QNA   - ATMOSPHERIC LONG WAVE RADIATION
C       QW    - LONG WAVE BACK RADIATION
C       QE    - EVAPORATIVE HEAT
C       QC    - SENSIBLE HEAT
      WRITE (6,630) QN,QNS,QNA,QW,QE,QC
      IF (NSEG.NE.NLETS) GO TO 490
      WRITE (6,640) (J,NOU(J),ELOUT(J),QOT(J),TOUT(J),DRODZ(J),J-1,NOUTS
     1)
490   MAX-INTP*75
      DO 500 J=1,NUME,MAX
      IGO=J+INTP-1
      IEND=IGO+MAX-1
      IF (IEND.GT.NUME) IEND=NUME
      NPAGE=NPAGE+1
      WRITE (6,550) NPAGE,NSEG,CMENT
      WRITE (6,650) M,MM
      WRITE (6,660)
      WRITE (6,670) (K,Z(K),TFX(K),TF(K),QHO(K),QHI(K),TDOT(K),DC(K),VZ(
     1K),VH(K),K=IGO,IEND,INTP)
500   CONTINUE
      RETURN
C     INPUT FORMAT STATEMENTS
C     OUTPUT FORMAT STATEMENTS
C
510   FORMAT (16A5)
520   FORMAT (8E10.0)
530   FORMAT (8I10)
540   FORMAT (16I5)
550   FORMAT (1H1,//,15X,'RESERVOIR SIMULATION PROGRAM',/,20X,'BATTELLE-
     1NORTHWEST',/,13X,'WATER RESOURCES SYSTEMS SECTION',/,12X,'P.O. BOX
560   FORMAT (//26X,4HTRIB,7X,3HSEG/(I30,I10))
     3I5,//,(20X,16A5))
     2 999, RICHLAND WASHINGTON',///,20X,'PAGE NO.',I5,/,20X,'SEGMENT ',
570   FORMAT (//,21X,9HFIRST DAY,I10/21X,9HFINAL DAY,I10//21X,9HNORMAL D
     1ZF10.3/20X,10HINITIAL ELF10.2/20X,10HMAXIMUM ELF10.1)
580   FORMAT (///,20X,10HSW EX COEF,1PE15.3/,22X,8HEX DEPTH,E15.3,/,18X,
     112HEVAP COEFF A,E15.3,/,18X,12HEVAP COEFF B,E15.3,/,22X,8HMAX STAB
     21PE15.3,/,22X,8HMIN STAB,1PE15.3)
590   FORMAT (///20X,10HSEG NUMBERI10/22X,8HAREA PTSI10/22X,8HTEMP PTSI1
      10/22X,8HDAYS OUTI10/19X,11HOUTPUT FREQI10/17X,13HVERT PRT FREQI10/
      222X,8HTAPE OUTI10//19X,11HOBS PER DAYI10//20X,10HREPEAT XFRI10/16X
      3,14HXEQ OUTPUT INTI10)
600    FORMAT (//25X,49HOUTFLOW     ELEMENT     ELEVATION       EFF WIDTH
      1/(I30,I12,1P2E16.3))
610    FORMAT (//13X,107HNO       ELEVATION        DELTA Z        SEC AREA
      1       CULM VOL       DELTA VOL    TEMPERATURE       TEMP RATE//(I15,
      21P7E15.3))
620    FORMAT (//14X,26HGENERAL SYSTEM INFORMATION//21X,19HRESERVOIR ELEV
      1ATIONF10.2,2H M17X,16HSURFACE AIR TEMPF12.2,6H DEG C/25X,15HSURFAC
      2E ELEMENTF10.2,2H M15X,18HSURFACE WATER TEMPF12.2,6H DEG C/21X,19H
      3TOTAL SYSTEM INFLOWF10.1,4H CMS13X,18HEVAPORIZATION RATE1PE12.2,4H
      4 CMS/20X,20HTOTAL SYSTEM OUTFLOW0PF10.1,4H CMS13X,18HCULM EVAPORIZ
      5ATIONF12.3,2H M/24X,16HELEV THERMOCLINEF10.1,2H M,14X,19HNET SURFA
      6CE HEATING1PE12.2,8H KC/M2/S/25X,15HDOWNSTREAM TEMP0PF10.2,6H DEG
      7C,12X,17HLOWEST MIXED ELEVF12.1,2H M/26X,14HRETENTION TIMEF10.1,5H
      8 DAYS,14X,16HTRIBUTARY INFLOWF12.1,4H CMS)
630    FORMAT (///18X,22HSURFACE HEAT EXCHANGES//38X,2HQN,1PE13.3,8H KC/M
      12/S/37X,3HQNS,E13.3,8H KC/M2/S/37X,3HQNA,E13.3,8H KC/M2/S/38X,2HQW
      2,E13.3,8H KC/M2/S/38X,2HQE,E13.3,8H KC/M2/S/38X,2HQC,E13.3,8H KC/M
      32/S)
640    FORMAT (///25X,15HSYSTEM OUTFLOWS//33X,57HNO       ELEM       ELEV
      1    FLOW      TEMP         DEN GRAD /(25X,2I10,0PF10.1,2F10.2,1PE15.3
      2))
650    FORMAT (/25X,36HSUMMARY OF OUTPUT FOR SIMULATION DAYI5,5X,13HEXECU
      1TION INTI5)
660    FORMAT (/8X,107HNO        ELEVATION      TEMP DEG C      TEMP DEG F
      1    HORZ OUT          HORZ IN    RATE OF CHG       DIFF COEF//)
670    FORMAT (I10,0PF15.1,4F15.4,1P2E15.3,0P2F7.2)
680    FORMAT (/10X,23HINPUT COMPLETE FOR FILEI4,5X,17HTHE FILE RANGE ISI
      14,3H TOI4,11H   FOR YEARI6)
690    FORMAT (///10X,13HERROR IN FILEI4,20H   THE FILE RANGE ISI4,4H  TO
      1I4)
700    FORMAT (/10X,7HFILE NOI4,15H IS POSITIONED )
710    FORMAT (///17X,13HCRITICAL STAB1PE15.3/17X,13HLOW GRAD COEFE15.3/2
      11X,9HINTERCEPTE15.3/22X,8HEXPONENTE15.3/20X,10HSEGMENT DZ0PF15.2/1
      28X,12HREACH LENGTH1PE15.3)
720    FORMAT (/10X,18HOUTLETS IN SEGMENTI5)
       END
      SUBROUTINE SUBC
C
C     SUBROUTINE SUBC FORMS AND SOLVES A SET OF SIMULTANEOUS  ORDINARY
C     DIFFERENTIAL EQUATIONS WHICH ESTABLISH THE TEMPERATURE STRUCTURE
C     FOR EACH RESERVOIR SEGMENT. IF THE SOLUTION TO THE BASIC HEAT
C     EQUATIONS RESULT IN A TEMPERATURE (DENSITY) PROFILE WHICH IS
C     CONSIDERED TO BE GRAVITATIONALLY UNSTABLE, THE CODE WILL COMMENCE
C     A RESERVOIR MIXING PROCESS UNTIL A STABLE PROFILE IS ACHIEVED.
C     SUBC IS CALLED ONCE FOR EACH SEGMENT SIMULATED.
C
      COMMON/ABLK/ ABAR(200), AREA(200), DC(200), DENS(200), DHI(200),
     1  DVOL(200), DZ(200), DZI(200), QHI(200), QHO(200), T(200),
     2  TDOT(200), TFX(200), THI(200), VOL(200), Z(200), ZMID(200)
      COMMON/BBLK/ A, HT, BB, EV, NAVG, QC, QE, WN, QNA, QNS, QN, WS
      COMMON/CBLK/ DST(365), POOL(365), QIN(365), RESTM(365), TIN(365)
      COMMON/DBLK/ DROD7(10), ELOUT(10), NOU(10), QOI(10), TOUT(10),
     1  WOT(10)
      COMMON/EBLK/ IDOUT(50), ITRIB(6)
      COMMON/FBLK/ EUP(5), QUP(5), TUP(5) , WUP(5)
      COMMON/NDV/ A1, A2, A3, DELT, DQIN, DTBY2, DZT, EDMAX, ELTC, EVA,
     1  EVAP, EXCO, GMAX, GMIN, GSWH, IAT, IBT, IDAY, IMIX, INTP, IONE,
     2  IPRT, ITAPE, ITWO, IVAL, LDAY, MAXE, MAXP, NLETS, NOBS, NOUTS,
     3  NTC, NREP, NSD, NSEG, NUM, NUME, NUMP, NUS1, NTRIBS, NXEQ, QI,
     4  QOUT, RESEL, RLEN, SDZ, SHEAT, STABLE, VONE, VSUM, VTOP, NTAPE,
     5  DZTOP
C
      DIMENSION AV(200), B(200), FEE(200), P(200), S(200,3), SW(200)
      DIMENSION QT(5), TAV(5), TBA(5), TWI(5)
      DIMENSION XQOT(365,10), XTOUT(365,10)
      LOGICAL ATRIB
C
      RO(TA)=1000.0-(((TA-3.98)**2*(TA+283.0))/(503.57*(TA+67.26)))
C
C     CALCULATE SOME MISCELLANEOUS QUANTITIES
C
      TA=1.0/SDZ
      DO 100 J=1,MAXE
      DZI(J)=TA
      ABAR(J)=0.50*(AREA(J)+AREA(J+1))
      TFX(J)=T(J)
100   CONTINUE
      DELT=3600.0*FLOAT(24/NXEQ)
      DTBY2=0.5*DELT
      NHOB=24/NOBS
      NHXQ=24/NXEQ
      NAVG=(NHXQ-1)/NHOB+1
      READ (IONE) NHUP
      NHUP=24/NHUP
      KOBS=(NHXQ-1)/NHUP+1
      IF (NSEG.NE.NLETS) WRITE (ITWO) NXEQ
C
```

```
C     INITIAL SEGMENT VOLUME
C
      DO 110 J=1,MAXE
      K=MAXP-J
      IF (RESEL.GT.Z(K)) GO TO 120
110   CONTINUE
120   NUMP=K+1
      NUME=K
      VSUM=VOL(K)+TA*DVOL(K)*(RESEL-Z(K))
      ATWO=AREA(K)+TA*(AREA(K+1)-AREA(K))*(RESEL-Z(K))
      EVAP-0.0
      IMIX=1
      IF (T(NUME-2)-T(1).GT.0.05) IMIX=NUME
      VTOP=VSUM-VOL(NUME)
C
C     CHECK FOR TRIBUTARY INFLOW TO THIS SEGMENT
C
      DO 130 J=1,363
      QIN(J)=0.0
      DST(J)=0.0
130   CONTINUE
      ATRIB=.FALSE.
      DO 140 J=1,NTRIBS
      IF (ITRIB(J).NE.NSEG) GO TO 140
      ATRIB=.TRUE.
      READ (4) (QIN(K),TIN(K),K=IAT,IBT)
      NUSI=NUSI+1
140   CONTINUE
      CVRT=3.2808**3
C
C     INITIAL OUTPUT TAPE WRITE
C
C     CREATE A DATA FILE FOR THE QUALITY SIMULATION
C
      IF (NTAPE.LE.0) GO TO 150
      WRITE (NTAPE) IDAY,LDAY,NUME,NXEQ
      WRITE (NTAPE) (AREA(J),J=1,NUME)
      IF (ATRIB) WRITE (NTAPE) IAT,IBT,(QIN(K),K=IAT,IBT)
C
150   IF (ITAPE.LE.0) GO TO 160
      WRITE (3) IDAY,LDAY,SDZ,NUUTS,NSEG,NLETS
C     WRITE(3)  ITAPE, NSEG, IDAY, LDAY
      K=IDAY-1
      WRITE (3) K,NUME,(T(J),J=1,NUME)
C
C     *  ENTER DAILY INTERVAL LOOP  *****
C
160   DO 640 L=IDAY,LDAY
C
C     READ THE O. F.  IF LAST SEGMENT
C
      IF (NSEG.NE.NLETS) GO TO 180
      READ (10) (QOT(J),J=1,NOUTS)
      DO 170 J-1,NOUTS
      XQOT(L,J)=QOT(J)
170   CONTINUE
C
C     SURFACE ELEMENT PROPERTIES
C
180   DO 190 J=1,MAXE
      K=MAXP-J
      IF (Z(K).LT.POOL(L)) GO TO 200
190   CONTINUE
200   DZT=POOL(L)-Z(K)
      AONE=ATWO
      ATWO=AREA(K)+DZT*(AREA(K+1)-AREA(K))/SDZ
      VONE-VSUM
      VSUM=VOL(K)+DVOL(K)*DZT/SDZ
      NUMP=K
      NUME=NUMP-1
      NUM-NUME-1
      NULL=NUM-1
      IF (IMIX.GT.NUME) IMIX=NUME
      RESEL=POOL(L)
      DZT=RESEL-Z(NUME)
      DZTOP=0.50*(DZT+DZ(NUM))
      VBAR=0.5*(VTOP+VSUM-VOL(NUME))
      VTOP=VSUM-VOL(NUME)
      ATOP=0.5*(AONE+ATWO)
      ABTOP=0.5*(ATOP+AREA(NUME))
C
C     * ENTER EXECUTION INTERVAL LOOP  *****
C
      DO 630 M=1,NXEQ
      NH=(M-1)*NHXQ
C
C     BRING IN M. I. F. AS REQUIRED
C
      IF (MOD(NH,NHOB).EQ.0) CALL SUBD (TFX(NUME))
C
C     READ UPSTREAM FLOW FILE AS REQUIRED
C
      IF (MOD(NH,NHUP).NE.0) GO TO 220
      DO 210 J=1,KOBS
      READ (IONE) QUP,TUP,WUP,EUP
210   CONTINUE
220   EVAP=EVAP+EV*DELT
      EVA=EV*ATOP
C
C     CALCULATE THE DENSITY PROFILE
C
      DO 230 J=1,NUME
      DENS(J)=RO(TFX(J))
230   CONTINUE
```

```
      DENS(NUMP)-DENS(NUME)
C
C     LOCATE THERMOCLINE
C
      NTC=NUME
      TA=0.0
      DO 240 J=1,NUM
      TB=DZI(J)*(TFX(J+1)-TFX(J))
      IF (TB.LT.TA) GO TO 240
      NTC=J
      TA=TB
240   CONTINUE
      ELTC=ZMID(NTC)
C
C     CALCULATE THE DIFFUSION COEFFICIENT
C
      DO 250 J=1,NUME
      DC(J+1)=A1
      TA=(2.0*DZI(J)*(DENS(J)-DENS(J+1)))/(DENS(J)+DENS(J+1))
      IF (TA.LE.GSWH) GO TO 250
      DC(J+1)=A2*TA**A3
250   CONTINUE
C
C     CALCULATE RATE OF HORIZONTAL ENERGY INPUT
C
      DO 260 J=1,MAXF
      AV(J)=0.0
      QHI(J)=0.0
      QHU(J)=0.0
      FEE(J)=0.0
260   CONTINUE
      CALL SUBH (L,FEE,200,ATRIB,MM)
      IF (NSEG.NE.NLETS) GO TO 290
      CALL SUBF (M,L)
      QR=((VSUM-VONE)/DELT+QOUT)/QI
      DO 270 J=1,NUME
      QHI(J)=QHI(J)+QR
      FEE(J)=FEE(J)*QR
270   CONTINUE
      QI=QI*WR
      DO 280 J=1,NOUTS
      XTOUT(L,J)=TOUT(J)
280   CONTINUE
C
C     CALCULATE RATE OF HORIZONTAL ENERGY WITHDRAWAL
C
290   DO 300 K=1,NUME
      FEE(K)=FEE(K)-QHO(K)*TFX(K)*DENS(K)
300   CONTINUE
      RESTM(L)=VSUM/(AMAX1(QI,QOUT)*8.64E4)
C
C     CALCULAT NET RATE OF VERTICAL ENERGY INPUT
```

```
C
      VERT=0.0
      DO 310 J=1,NUME
      K=J-1
      IF (VERT.LE.0.0) K=J
      AV(J)=VERT*DENS(K)*TFX(K)
      IF (J.EQ.NUME) GO TO 310
      VERT=VERT+QHI(J)-QHO(J)
      K=J
      IF (VERT.LT.0.0) K=J+1
      AV(J)=AV(J)-VERT*DENS(K)*TFX(K)
  310 CONTINUE
      IF (VERT.GT.0.0) AV(NUME)=VERT*DENS(NUM)*(TFX(NUM)-TFX(NUME))
C
C     CALCULATE RATE OF SOLAR ENERGY INPUT
C
      TA=RESEL-0.3
      TB=RESEL-EDMAX
      DO 320 J=1,NUME
      K-NUMP-J
      IF (Z(K).LT.TB) GO TO 330
      SW(K)=EXP(EXCO*(Z(K)-TA))
  320 CONTINUE
  330 QSW=0.6*QNS
      DO 340 J=1,K
      SW(J)=0.0
  340 CONTINUE
      DO 350 J-K,NUM
      SW(J)=ABAR(J)+QSW*(SW(J+1)-SW(J))
  350 CONTINUE
      SW(NUME)=ABTOP+QSW*(1.0-SW(NUME))
C
C     CALCULATE RATE OF SURFACE ENERGY INPUT
C
      SHEAT=QN-0.6*QNS-QE-QC
C
C     FORM SOLUTION MATRICES
C
      DO 360 J=1,NUME
      P(J)-FEE(J)+AV(J)+SW(J)
  360 CONTINUE
      P(NUME)=P(NUME)+SHEAT*ATOP
      DO 370 J=1,NUME
      B(J)=T(J)+DTBY2*TDOT(J)
  370 CONTINUE
      TA=AREA(2)*DC(2)*DZI(1)
      S(1,1)=0.0
      S(1,2)=TA
      S(1,3)=-S(1,2)
      DO 380 J=2,NULL
      TB=AREA(J+1)*DC(J+1)*DZI(J)
      S(J,1)=-TA
      S(J,3)=-TB
      S(J,2)=-(S(J,1)+S(J,3))
      TA=TB
380   CONTINUE
      TA=AREA(NUM)*DC(NUM)*DZI(NULL)
      TB=AREA(NUME)*DC(NUME)/DZTOP
      S(NUM,1)=-TA
      S(NUM,3)=-TB
      S(NUM,2)=-(S(NUM,1)+S(NUM,3))
      S(NUME,1)=-TB
      S(NUME,2)=TB
      S(NUME,3)=0.0
      P(1)=P(1)-(S(1,2)*B(1)+S(1,3)*B(2))
      DO 390 J=2,NUME
      P(J)=P(J)-(S(J,1)*B(J-1)+S(J,2)*B(J)+S(J,3)*B(J+1))
390   CONTINUE
      DO 400 J=1,NUME
      S(J,1)=DTBY2*S(J,1)
      TA=DVOL(J)
      IF (J.EQ.NUME) TA=VBAR
      S(J,2)=DTBY2*S(J,2)+DENS(J)*TA
      S(J,3)=DTBY2*S(J,3)
400   CONTINUE
C
C     SOLVE FOR FINAL TEMPERATURES
C
      P(1)=P(1)/S(1,2)
      S(1,3)=S(1,3)/S(1,2)
      DO 410 J=2,NUME
      TA=S(J,2)-S(J,1)*S(J-1,3)
      P(J)=(P(J)-S(J,1)*P(J-1))/TA
      S(J,3)=S(J,3)/TA
410   CONTINUE
      TDOT(NUME)=P(NUME)
      T(NUME)=B(NUME)+DTBY2*TDOT(NUME)
      DO 420 J=2,NUME
      N=NUMP-J
      TDOT(N)=P(N)-S(N,3)*TDOT(N+1)
      T(N)=B(N)+DTBY2*TDOT(N)
420   CONTINUE
C
C     SMOOTH THE PROFILE
C     TFX(1) = 0.50 * ( T(1) + T(2) )
C
      TFX(1)=T(1)
      TFX(NUME)=T(NUME)
      DO 430 J=2,NUM
      TFX(J)=0.3333333*(T(J-1)+T(J)+T(J+1))
430   CONTINUE
      DO 440 J=1,NUM
      T(J)=TFX(J)
440   CONTINUE
```

```
C
C     MIX THE RESERVOIR AS REQUIRED
C
      IMIX=NUME
      GTEM=GMIN
 450  DO 460 J=1,NULL
      NN=J
      GRAD=(T(J+1)-T(J))*DZI(J)
      IF (GRAD.GT.GTEM.AND.GRAD.LT.GMAX) GO TO 460
      GO TO 470
 460  CONTINUE
      NN=NUM
      GRAD=(T(NUME)-T(NUM))/DZTOP
      IF (GRAD.GT.GTEM.AND.GRAD.LT.GMAX) GO TO 500
 470  IMIX=NN
      GTEM=-1.0E-3
      TA=VTOP*T(NUME)
      DO 480 J=IMIX,NUM
      TA=TA+DVOL(J)*T(J)
 480  CONTINUE
      TA=TA/(VSUM-VOL(IMIX))
      DO 490 J=IMIX,NUME
      T(J)=TA
      TFX(J)=TA
 490  CONTINUE
      GO TO 450
C
C     UPDATE FOR ELEMENT INCREASE
C
 500  DO 510 J=NUME,MAXE
      T(J)=T(NUME)
      TDOT(J)=TDOT(NUME)
      TFX(J)=T(NUME)
 510  CONTINUE
C
C     WRITE THE DOWNSTREAM FILE
C
      IF (NSEG.EQ.NLETS) GO TO 590
      DO 520 J=1,5
      QT(J)=0.0
      TAV(J)=0.0
      TBA(J)=0.0
      TNT(J)=0.0
 520  CONTINUE
      NUP=0
      N=0
 530  ILO=NUP+1
      DO 540 J=ILO,NUME
      NLO=J
      IF (QHI(J).GT.1.0E-4) GO TO 550
 540  CONTINUE
      GO TO 590
```

```
550   N=N+1
      DO 560 J-NLO,NUMF
      NUP-J
      IF (QHI(J+1).LT.1.0E-4) GO TO 570
560   CONTINUE
570   DO 580 J=NLO,NUP
      QT(N)=QT(N)+QHO(J)
      TAV(N)=TAV(N)+TFX(J)
      TWT(N)=TWT(N)+QHO(J)*TFX(J)
580   CONTINUE
      TAV(N)=TAV(N)/FLOAT(NUP-NLO+1)
      TWT(N)-TWT(N)/QT(N)
      TBA(N)-TFX(NLO)
      IF (NUP.LT.NUME) GO TO 530
      WRITE (ITWO) QT,TAV,TWT,TBA
      DST(L)-TAV(1)
C
C     CHECK FOR OUTPUT INTERVAL
C
530   IF (M.NE.IVAL) GO TO 630
      IA=0
      IF (MOD(L,IPRT).EQ.0) IA=1
      DO 600 J=1,NSD
      IF (IDOUT(J).EQ.L) IA=1
600   CONTINUE
C
C     CALCULATE DOWNSTREAM TEMPERATURE
C
      IF (NSEG.NE.NLETS) GO TO 620
      TA=0.0
      DO 610 J=1,NOUTS
      TA=TA+QOT(J)*TOUT(J)
610   CONTINUE
      DST(L)=TA/QOUT
      IF (NTAPE.EQ.0) GO TO 620
C
C        CREATE A DATA FILE FOR QUALITY SIMULATION
C
      WRITE (NTAPE) NUME,DZT,WS
      WRITE (NTAPE) (QHI(J),J=1,NUME)
      WRITE (NTAPE) (QHO(J),J=1,NUME)
      WRITE (NTAPF) (TFX(J),J-1,NUME)
620   IF (IA.GT.0) CALL PRNT (L,M)
      IF (ITAPE.GT.0) WRITE (3) L,NUME,(TFX(J),J=1,NUME)
630   CONTINUE
640   CONTINUE
      IF (NTAPE.NE.0) WRITE (6,650) NTAPE
      IF (ITAPE.GT.0) END FILE 3
      IF (NTAPE.GT.0) END FILE NTAPE
      IF (NSEG.NE.NLETS) RETURN
      IF (ITAPE.LE.0) RETURN
      WRITE (3) ((XQOT(J,K),K=1,NOUTS),J=IDAY,LDAY)
      WRITE (3) ((XTOUT(J,K),K=1,NOUTS),J=IDAY,LDAY)
      END FILE 3
      REWIND 3
      REWIND NTAPE
C
650   FORMAT (//,20X,'DATA FILE FOR QUALITY SIMULATION HAS BEEN WRITTEN
     1TAPE NO. ',I4,//)
      END
      SUBROUTINE SUBD (TA)
C
C     SUBROUTINE SUBD CALCULATES THE AIR-WATER HEAT TRANSFER QUANTITIES
C     WHICH ARE DEPENDENT ON SURFACE WATER TEMPERATURE. THE SURFACE
C     TEMPERATURE FROM THE PREVIOUS STEP IS USED AS AN ESTIMATE OF THE
C     CORRECT VALUE.
C
      COMMON/BBLK/ A, AT, BB, EV, NAVG, QC, QE, QN, QNA, QNS, QW, WS
      REAL DATA(8,6)
C
C     CALCULATE HV, ROS, ES
C
      HV=597.0-0.57*TA
      ROS=1000.0-(((TA-3.98)**2*(TA+283.0))/(503.57*(TA+67.26)))
      ES=2.1718E8*EXP(-4157.0/(TA+239.09))
C
C     READ WEATHER RECORD FROM UNIT 9
C
      DO 100 J=1,NAVG
      READ (9) (DATA(J,K),K=1,6)
100   CONTINUE
C
C     AVERAGE INPUT DATA AS REQUIRED
C
      IF (NAVG.LE.1) GO TO 130
      TC=1.0/FLOAT(NAVG)
      DO 120 K=1,6
      TB=0.0
      DO 110 J=1,NAVG
      TB=TB+DATA(J,K)
110   CONTINUE
      DATA(1,K) = TC * TB
120   CONTINUE
130   QNS=DATA(1,1)
      QNA=DATA(1,2)
      AP=DATA(1,3)
      AT=DATA(1,4)
      EA=DATA(1,5)
      WS=DATA(1,6)
C
C     CALCULATE QE, QC, AND QW
C
      EV=(WS*BB+A)*(ES-EA)
      IF (EV.LT.0.0) EV=0.0
      QE=ROS*HV*EV
      RB=6.1E-4*AP*(TA-AT)/(ES-EA)
      QC=QE*RB
      QW=7.36E-2+1.17E-3*TA
      QN=QNS+QNA-QW
      RETURN
      END
      SUBROUTINE SUBE (M,L)
C
C     SUBROUTINE SUBE CALCULATES THE DIMENSION AND LOCATION IN THE
C     LAYER FROM WHICH WATER IS WITHDRAWN FOR ANY SPECIFIED RATE OF
C     OUTFLOW AND OUTLET ELEVATION.  THE CALCULATION OF THE WITHDRAWAL
C     LAYER FOR AN OUTLET IN THE STRATIFIED ZONE IS BASED ON THE WORK OF
C     DEBLER AND A UNIFORM VELOCITY IS ASSUMED WITHIN IN THE SPECIFIED
C     LAYER.  IN THE CASE OF DISCHARGE FROM AN OUTLET LOCATED WITHIN THE
C     ZONE OF CONVECTIVE MIXING, CRITERIA SUGGESTED BY CRAYA IS EMPLOYED
C     TO CALCULATE THE NATURE OF THE OUTFLOW.  IN THE MIXED CASE A UNI-
C     FORM VELOCITY IS ASSUMED TO EXIST THROUGHOUT THE ENTIRE MIXED
C     DEPTH.  THE COMPUTED OUTPUT FROM SUBE CONSISTS OF AN ESTIMATE OF
C     THE FLOW HORIZONTALLY WITHDRAWN FROM EACH ELEMENT IN THE SEGMENT,
C     AND THE TEMPERATURE OF THE FLOW EXPECTED AT EACH DISCHARGE LEVEL.
C
      COMMON/ABLK/ ABAR(200), AREA(200), DC(200), DENS(200), DHI(200),
     1  DVOL(200), DZ(200), DZI(200), QHI(200), QHO(200), T(200),
     2  TDOT(200), TFX(200), THI(200), VOL(200), Z(200), ZMID(200)
      COMMON/CBLK/ DST(365), POOL(365), QIN(365), RESTM(365), TIN(365)
      COMMON/DBLK/ DRODZ(10), ELOUT(10), NOU(10), QOT(10), TOUT(10),
     1  WOT(10)
      COMMON/NDV/ A1, A2, A3, DELT, DQIN, DIBY2, DZT, EDMAX, ELTC, EVA,
     1  EVAP, EXCO, GMAX, GMIN, GSWH, IAT, IBT, IDAY, IMIX, INIP, IUNE,
     2  IPRT, ITAPE, ITWO, IVAL, LDAY, MAXE, MAXP, NLEIS, NOBS, NOUTS,
     3  NTC, NREP, NSD, NSEG, NUM, NUME, NUMP, NUSI, NTRIBS, NXEQ, WI,
     4  QOUT, RESEL, RLEN, SDZ, SHEAT, STABLE, VONE, VSUM, VTOP, NAME,
     5  DZTOP
      REAL TQHO(200)
C
C     INITIALIZE OUTFLOW ARRAY
C
      DO 100 J=1,NUME
      QHO(J)=0.0
100   CONTINUE
C
C     ENTER MAIN DISTRIBUTION LOOP
C
      QOUT=0.0
      DO 250 J=1,NOUTS
      N=NOU(J)
      DRODZ(J)=0.0
      TOUT(J)=TFX(N)
      IF (ELOUT(J).GT.RESEL) TOUT(J)=0.0
      IF (QOT(J).LE.0.0) GO TO 250
      QOUT=QOUT+QOT(J)
      IF (N.GT.NUME) N=NUME
      DO 110 K=1,NUME
      TQHO(K)=0.0
110   CONTINUE
      UNITQ=QOT(J)/WOT(J)
      GDEB=QOT(J)
      ICRAY=0
      JMIN=1
      JMAX=NUME
      IF (IMIX.LT.N) GO TO 200
C
C     NOT MIXED  **  USE DEBLERS CRITERIA
C
      MAX=N+7
      IF (MAX.GT.NUME) MAX=NUME
120   TA=-BETA(N-7,MAX,DENS,200)
      DRODZ(J)=TA
      IF (TA.GT.0.0) GO TO 140
C
C     NEGATIVE OR ZERO DENSITY GRADIENT
C
      NLO=N
      NUP=N
130   IF (NLO.GT.1) NLO=NLO-1
      IF (NUP.LT.NUM) NUP=NUP+1
      TA=(DENS(NLO)-DENS(NUP))/(ZMID(NUP)-ZMID(NLO))
      IF (TA.GT.0.0) GO TO 140
      IF (NLO.LE.1.AND.NUP.GE.NUM) GO TO 180
      GO TO 130
C
C     CALCULATE WITHDRAWAL DEPTH
C
140   IF (N.NE.1.AND.N.NE.NUME.AND.ICRAY.EQ.0) UNITQ=0.5*UNITQ
      DT=SQRT(42.0*UNITQ/TA**0.5)
      IF (ICRAY.GT.0) GO TO 160
      TA=ZMID(N)+DT
      IF (TA.GT.Z(NUME)) GO TO 160
      DO 150 K=1,NUME
      JMAX=NUME-K
      IF (Z(JMAX).LT.TA) GO TO 160
150   CONTINUE
160   TA=ZMID(N)-DT
      IF (TA.LT.Z(2)) GO TO 180
      DO 170 K=3,NUMP
      IF (Z(K).LT.TA) GO TO 170
      JMIN=K-1
      GO TO 180
170   CONTINUE
      JMIN=NUME
C
C     DISTRIBUTE OUTFLOWS
C
180   TA=VOL(JMAX+1)-VOL(JMIN)
      IF (JMAX.GE.NUME) TA=VSUM-VOL(JMIN)
      TA=QDEB/TA
      DO 190 K=JMIN,JMAX
      TQHO(K)=TA*DVOL(K)
      IF (K.EQ.NUME) TQHO(K)=TA*VTOP
      QHO(K)=QHO(K)+TQHO(K)
190   CONTINUE
      GO TO 230
C
C     CONVECTIVE MIXED OUTFLOW      **********
C
200   IF (IMIX.LE.2) GO TO 180
      TA=DENS(1)-DENS(IMIX)
      IF (TA.LE.0.0) GO TO 180
      QDEB=0.0
      TC=0.1505
      IF (N.EQ.NUME) TC=0.0742
      DT=RESEL-Z(IMIX)
      QCRIT=TC*DT*SQRT(DT*TA)
      QCRAY=QOT(J)
      IF (QCRIT.GE.UNITQ) GO TO 210
      QCRAY=QOT(J)*QCRIT/UNITQ
      QDEB=QOT(J)-QCRAY
      ICRAY=1
      UNITQ=QDEB/WOT(J)
210   TA=QCRAY/(VSUM-VOL(IMIX))
      DO 220 K=IMIX,NUM
      TQHO(K)=TA*DVOL(K)
      QHO(K)=QHO(K)+TQHO(K)
220   CONTINUE
      TQHO(NUME)=TA*VTOP
      QHO(NUMF)=QHO(NUME)+TQHO(NUME)
      IF (ICRAY.LE.0) GO TO 230
      JMAX=IMIX-1
      N=IMIX-1
      MAX=JMAX
      GO TO 120
230   IF (M.NE.IVAL) GO TO 250
C
C     CALCULATE OUTFLOW TEMPERATURE
C
      TA=0.0
      DO 240 K=1,NUME
      TA=TA+TQHO(K)*TFX(K)
240   CONTINUE
      TOUT(J)=TA/QOT(J)
250   CONTINUE
      RETURN
      END
      FUNCTION BETA( MIN, MAX,DATA, N )
C
C     FUNCTION BETA PERFORMS A LEAST SQUARES FIT TO A SET OF DATA POINTS
C     BETA RETURNS THE VALUE OF THE GRADIENT: AN APPROXIMATION OF THE
C     EXISTING DENSITY GRADIENT AT ANY POINT IN SPACE AND TIME.
C
      COMMON/ABLK/ ABAR(200), AREA(200), DC(200), DENS(200), DHI(200),
     1  DVOL(200), DZ(200), DZI(200), QHI(200), QHO(200), T(200),
     2  TDOT(200), TFX(200), THI(200), VOL(200), Z(200), ZMID(200)
      DIMENSION DATA(200)
C
      IF (MIN.LT.1) MIN=1
      XBAR=0.0
      YBAR=0.0
      TA=0.0
      TB=0.0
C
C     CALCULATE MEANS
C
      DO 100 J=MIN,MAX
      XBAR=XBAR+ZMID(J)
      YBAR=YBAR+DATA(J)
100   CONTINUE
      XBAR=XBAR/FLOAT(MAX-MIN+1)
      YBAR=YBAR/FLOAT(MAX-MIN+1)
C
C     CALCULAT SLOPE OF LEAST SQUARES FIT
C
      DO 110 J=MIN,MAX
      TC=ZMID(J)-XBAR
      TA=TA+TC*(DATA(J)-YBAR)
      TB=TB+TC*TC
110   CONTINUE
      BETA=TA/TB
      RETURN
      END
      SUBROUTINE SUBG (NP,DATA,N)
C
C     SUBROUTINE SUBG APPROXIMATES THE CONTINUOUS RELATION FOR
C     (1)SEGMENT AREA AND ELEVATION,(2)INITIAL TEMPERATURE AND ELEVATION
C     (3)INITIAL RATE OF TEMPERATURE CHANGE AND ELEVATION, AS A SERIES
C     OF STRAIGHT LINES.  THE ELEVATION OF THE FIRST POINT INPUT MUST
C     CORRESPOND TO A SEGMENT'S LOWEST ELEVATION.
C
      COMMON/ABLK/ ABAR(200), AREA(200), DC(200), DENS(200), DHI(200),
     1  DVOL(200), DZ(200), DZI(200), QHI(200), QHO(200), T(200),
     2  TDOT(200), TFX(200), THI(200), VOL(200), Z(200), ZMID(200)
      DIMENSION DATA(200)
C
C     DEFINE END POINTS
C
      DH=0.0
      M=1
      DO 130 J=2,NP
      NLO=M+1
      DO 100 K=NLO,N
      IF (DATA(K).EQ.0.0) GO TO 100
      DH=(DATA(K)-DATA(M))/(Z(K)-Z(M))
      M=K
      GO TO 110
100   CONTINUE
C
C     INTERPOLATE BETWEEN POINTS
C
110   DO 120 K=NLO,M
      DATA(K) = DATA(K-1) + DH * DZ(K-1)
120   CONTINUE
130   CONTINUE
      RETURN
      END
      SUBROUTINE SUBH (L,FEE,M,ATRIB,MM)
C
C     SUBROUTINE SUBH CALCULATES THE DEPTH AND POSITION OF THE FLOWING
C     LAYER(S) ASSUMED BY A SEGMENT'S UPSTREAM AND TRIBUTARY INFLOWS.
C     THE LAYER IS POSITIONED FROM AND CENTERED ABOUT A DENSITY MATCH
C     BETWEEN THE MEAN UPSTREAM INFLOW DENSITY AND THE CURRENT DENSITY
C     WITHIN THE SEGMENT.  IF THE CALCULATED POSITION OF THE FLOWING
C     LAYER EXTENDS OUTSIDE THE PHYSICAL LIMITS OF THE SEGMENT, THE
C     LAYER IS MOVED TO THE MOST NEARLY CORRECT POSITION AND MAINTAINS
C     ITS OVERALL VERTICAL DIMENSION.  IF THE INFLOW SEEKS THE ZONE IN
C     WHICH MIXING HAS OCCURED, A UNIFORM FLOW VELOCITY IS ASSUMED OVER
C     THE ENTIRE MIXED REGION.  THE OUTPUT CONSISTS OF THE CURRENT VALUE
C     OF HORIZONTAL INFLOW AND OUTFLOW FROM EACH ELEMENT, AND THE VALUE
C     FOR THE RATE AT WHICH ENERGY IS HORIZONTALLY ADVECTED INTO EACH
C     ELEMENT.
C
      COMMON/ABLK/ ABAR(200), AREA(200), DC(200), DENS(200), DHI(200),
     1  DVOL(200), DZ(200), DZI(200), QHI(200), QHO(200), T(200),
     2  TDOT(200), TFX(200), THI(200), VOL(200), Z(200), ZMID(200)
      COMMON/CALK/ DST(365), POOL(365), QIN(365), RESTM(365), TIN(365)
      COMMON/DBLK/ DRODZ(10), ELOUT(10), NOU(10), QOT(10), TOUT(10),
     1  WOT(10)
      COMMON/FBLK/ EUP(5), QUP(5), TUP(5), WUP(5)
      COMMON/NDV/ A1, A2, A3, DELT, DQIN, DTBY2, DZT, EDMAX, ELTC, EVA,
     1  EVAP, EXCO, GMAX, GMIN, GSWH, IAT, IBT, IDAY, IMIX, INTP, IONE,
     2  IPRT, ITAPE, ITWO, IVAL, LDAY, MAXE, MAXP, NLETS, NOBS, NOUTS,
     3  NTC, NREP, NSD, NSEQ, NUM, NUME, NUMP, NUSI, NTRIBS, NXEQ, QI,
     4  QOUT, RESEL, RLEN, SDZ, SHEAT, STABLE, VONE, VSUM, VTOP, NTAPE,
     5  DZTOP
C
      DIMENSION FEE(200)
      LOGICAL ATRIB
      DATA DEGREE/1.00/
C
      RO(TA)=1000.0-(((TA-3.98)**2*(TA+283.0))/(503.57*(TA+67.26)))
      IF (.NOT.ATRIB) GO TO 100
      QUP(NUSI)=QIN(L)
      TUP(NUSI)=TIN(L)
      EUP(NUSI)=TIN(L)
      WUP(NUSI)=TIN(L)
  100 QI=0.0
      JMIN=1
      JMAX=NUME
      IDO=0
      DO 110 J=1,NUSI
      QI=QI+QUP(J)
  110 CONTINUE
      QOUT=QI-(VSUM-VONE)/DELT
      IF (QI.LT.1.0E-20) WRITE (6,370) QI,L,M,NUSI
      QR=QOUT/QI
      DO 270 K=1,NUSI
      IF (QUP(K).LT.1.0E-4) GO TO 270
      IDO=IDO+1
C
C     FIND ENTRY LEVEL
C
      RUP=RO(TUP(K))
      DO 120 J=1,NUME
      N=J
      IF (RUP.GT.DENS(J)) GO TO 130
120   CONTINUE
C
C     CHECK REGIONS
C
130   IF (N.LT.IMIX.OR.IMIX+4.GT.NUME) GO TO 150
      JMIN=IMIX
      TA=QUP(K)*DELT
      IF (VSUM-VOL(IMIX).GT.TA) GO TO 220
      DO 140 J=1,NUME
      JMIN=NUMP-J
      IF (VSUM-VOL(JMIN).GT.TA) GO TO 220
140   CONTINUE
      GO TO 220
C
C     ESTABLISH THE DENSITY GRADIENT
C
150   MAX=N+7
      IF (MAX.GT.NUME) MAX=NUME
      TA=-BETA(N-7,MAX,DENS,200)
      IF (TA.GT.0.0) GO TO 170
      NLO=N
      NUP=N
160   IF (NLO.GT.1) NLO=NLO-1
      IF (NUP.LT.NUM) NUP=NUP+1
      TA=(DENS(NLO)-DENS(NUP))/(ZMID(NUP)-ZMID(NLO))
      IF (TA.GT.0.6) GO TO 170
      IF (NLO.LE.1.AND.NUP.GE.NUM) GO TO 220
      GO TO 160
C
C     CALCULATE WITHDRAWALS
C
170   TA=SQRT(TA)
      UNITQ=0.5*QUP(K)*RLEN/AREA(N)
      DT=SQRT(42.0*UNITQ/TA)
      IFLO=DT/SDZ+0.5555555555
      IF (IFLO.LE.0) IFLO=1
      IF (2*IFLO.GE.NUM) GO TO 220
      JMAX=N+IFLO
      IF (N+IFLO.GT.NUME) JMAX=NUME
      JMIN=N-IFLO
      IF (JMIN.LT.1) JMIN=1
      IF (JMAX.EQ.NUME) JMIN=NUMP-2*IFLO
      IF (JMIN.EQ.1) JMAX=2*IFLO
      DO 180 ICK=JMIN,1,-1
      JJMIN=ICK
180   IF ((TFX(N)-TFX(ICK)).GT.DEGREE) GO TO 190
190   DO 200 ICK=JMAX,NUME
      JJMAX=ICK
200   IF ((TFX(ICK)-TFX(N)).GT.DEGREE) GO TO 210
210   JMIN=JJMIN
      JMAX=JJMAX
220   TA=VOL(JMAX+1)-VOL(JMIN)
      IF (JMAX.GE.NUME) TA=VSUM-VOL(JMIN)
      IF (TA.LT.1.0E-20) WRITE (6,370) TA,K,L,NUP,JMIN,JMAX
      TB=QUP(K)/TA
      TA=0.0
      DO 240 J=JMIN,JMAX
      IF (J.GE.NUME) GO TO 230
      TA=TA+TB*DVOL(J)*ZMID(J)
      GO TO 240
230   TA=TA+TB*VTOP*(ZMID(NUM)+DZTOP)
240   CONTINUE
      DTDZ=(WUP(K)-EUP(K))/(TA/QUP(K)-ZMID(JMIN))
      DO 260 J=JMIN,JMAX
      IF (J.GE.NUME) GO TO 250
      TC=TB*DVOL(J)
      QHI(J)=QHI(J)+TC
      FEE(J)=FEE(J)+TC*RUP*(EUP(K)+DTDZ*(ZMID(J)-ZMID(JMIN)))
      GO TO 260
250   TC=TB*VTOP
      QHI(J)=QHI(J)+TC
      FEE(J)=FEE(J)+TC*RUP*(EUP(K)+DTDZ*(ZMID(NUM)+DZTOP-ZMID(JMIN)))
260   CONTINUE
270   CONTINUE
      IF (NSEG.EQ.NLETS.AND.IDO.LE.1) RETURN
      IF (IDO.GT.1) GO TO 290
      DO 280 J=1,NUME
      IF (QHI(J).GT.1.0E-4) QHO(J)=QHI(J)*QR
280   CONTINUE
      RETURN
C
C     LOCATE REGIONS OF INTERFLOW
C
290   N=0
      NUP=0
300   ILO=NUP+1
      DO 310 J=ILO,NUME
      NLO=J
      IF (QHI(J).GT.1.0E-4) GO TO 320
310   CONTINUE
      RETURN
320   DO 330 J=NLO,NUME
      NUP=J
      IF (QHI(J+1).LT.1.0E-4) GO TO 340
330   CONTINUE
```

```
C
C     REDISTRIBUTE FLOWS
C
340   N=N+1
      TA=0.0
      TB=0.0
      DO 350 J=NLO,NUP
      TA=TA+QHI(J)
      TB=TB+FEE(J)
350   CONTINUE
      TD=VOL(NUP+1)-VOL(NLO)
      IF (NUP.GE.NUME) TD=VSUM-VOL(NLO)
      TA=TA/TD
      TB=TB/TD
      DO 360 J=NLO,NUP
      TV=DVOL(J)
      IF (J.EQ.NUMF) TV=VTOP
      QHI(J)=TA*TV
      FEE(J)=TB*TV
      QHO(J)=QHI(J)*QR
360   CONTINUE
      IF (NUP.LT.NUME) GO TO 300
      RETURN
C
C
370   FORMAT (1X,'DIVIDE CHECK ERROR',F10.2,10I5)
      END
```

FIGURE C-37. PROGRAM LISTING FOR AQUA

```
C     AQUA:
C     A COMPUTER CODE FOR SIMULATING THE WATER QUALITY OF RESERVOIRS
C     AND THERMAL IMPOUNDMENTS OF THE LOW DISCHARGE TO VOLUME TYPE,
C     WITH LOW FROUDE NUMBERS.  A MAXIMUM OF 200 ELEMENTS IS PERMITTED.
C     THIS PROGRAM IS DESIGNED TO INTERFACE WITH MOST AVAILABLE THERMAL-
C     HYDRAULIC RESERVOIR SIMULATION PROGRAMS:
C
C        1.  H. CLAYS'S MODEL
C        2.  P. J. RYAN'S MODEL
C        3.  W. R. E. DEEP RESERVOIR MODEL (CORPS OF ENGRS. VERSION)
C        4.  W. R. E. WEAKLY STRATIFIED RESERVOIR MODEL (E. P. A. VERSION)
C
C      REFERENCES:
C
C          1.  CLAY, H. M. , 'SELECTIVE WITHDRAWL AT LAKE LIVINGSTON - AN
C              IMPOUNDMENT WATER QUALITY MODEL EMPHASIZING SELECTIVE
C              WITHDRAWL', UNIVERSITY OF TEXAS AT AUSTIN, NOV. 1970.
C
C          2.  RYAN, P. J. , 'PREDICTION OF THE ANNUAL CYCLE OF TEMPERATURE
C              CHANGES IN A STRATIFIED LAKE OR RESERVOIR: MATHEMATICAL
C              MODEL AND USER'S GUIDE', MIT DEPT. OF HYDROLOGY LAB. , TECH.
C              REPORT NO. 137, APRIL 1971.
C
C          3.  'APPLICATION OF WRE RESERVOIR TEMPERATURE SIMULATION
C              MODEL', NORTH PORTLAND DIVISION, CORPS OF ENGINEERS,
C              210 CUSTOM HOUSE, PORTLAND OREGON.  (NPD COMPUTER PROGRAM
C              723-K5 G0067), SEPTEMBER 1970.
C
C          4.  'PREDICTION OF THERMAL ENERGY DISTRIBUTION IN STREAMS AND
C              RESERVOIRS', PREPARED FOR THE DEPT. OF FISH AND GAME, STATE
C              OF CALIF. , BY WATER RESOURCES ENGINEERS, INC. , REVISED
C              30 AUGUST 1968.
C
C          5.  'MATHEMATICAL MODELS FOR THE PREDICTION OF THERMAL ENERGY
C              CHANGES IN IMPOUNDMENTS', PREPARED FOR THE E P. A. BY W. R. E.
C              DECEMBER 1969.
C
C
C       PROGRAMMED BY R. G.  BACA
C       WATER RESOURCES SYSTEMS SECTION, BATTELLE-NORTHWEST
C       P. O. BOX 999, RICHLAND, WASHINGTON 99352
C
        COMMON/BLK2/MODALG, MODBOD, MODDOX, MODTIN, MODPHO
        COMMON/BLK3/ALGIN, BENIN, BODIN, PHOIN, SPRIN, TOCIN, TOXIN, TININ
        COMMON/BLK8/DEPTH, TEMPR
        COMMON/BLK10/IPRINT, NPRINT, NTAPE1, NTAPE2, NTAPE3, TITLE, LOGIC
        COMMON/BLK11/SORCE, NTRIBS
C
        DIMENSION CARDS(16), ITAB(25), TITLE(32), COEF(1, 17), LIMIT(8)
        DIMENSION C(202, 16), CCIN(202, 16), SORCE(1, 16)
        DIMENSION ALGIN(1, 17), BENIN(1, 2), BODIN(1, 6), PHOIN(1, 3),
     1          SPRIN(1,5),TOCIN(1,6),TOXIN(1,3),TININ(1,3)
      DIMENSION CTRIB(16),NTRIBS(5)
C
      INTEGER SWITCH
C
      DATA NDRUM1/1/,NDRUM2/2/,NDRUM3/3/,NDPUM4/20/
      DATA TEST/5HEND  /,JSUM/36/,NSEQ/1/
      DATA LIMIT/17,6,2,3,3,5,6,3/
      DATA MM,NN,MAXCON/202,1,16/
      CALL SETDR (NDRUM1,300000,100000,ITAB(1))
      CALL SETDR (NDRUM2,400000,100000,ITAB(6))
      CALL SETDR (NDRUM3,500000,100000,ITAB(15))
      CALL SETDR (NDRUM4,600000,100000,ITAB(22))
      REWIND NDRUM1
      REWIND NDRUM2
      REWIND NDRUM3
      REWIND NDRUM4
      ISUM=0
C
C     WRITE INPUT CARD IMAGES TO DRUM AND PRINTER
C
      WRITE (6,630)
      WRITE (6,640)
      WRITE (6,650)
      L=1
100   READ (5,660,END=610) (CARDS(I),I-1,16)
      WRITE (6,670) L,(CARDS(I),I-1,16)
      IF (CARDS(1).EQ.TEST) GO TO 110
      WRITE (NDRUM1,660) (CARDS(I),I=1,16)
      L=L+1
      GO TO 100
110   CONTINUE
      END FILE NDRUM1
      REWIND NDRUM1
      WRITE (6,700)
      WRITE (6,720)
C
C     READ AND WRITE SIMULATION DATA
C
C        CARD 1-2
C     TITLE.........COMMENT CARDS(2) IDENTIFYING THE SIMULATION
C        (16A5/16A5)
      READ (NDRUM1,660) (TITLE(I),I=1,32)
      WRITE (6,710) (TITLE(I),I=1,32)
C
C        READ PROBLEM SPECIFICATIONS
C
C        CARD 3
C     IDAY..........FIRST DAY IN THE SIMULATION PERIOD
C     LDAY..........FINAL DAY IN THE SIMULATION PERIOD
C     LOGIC.........TRANSPORT MODEL ONLY(>0),DEFAULT: W/ QUALITY MODELS
C     IPRINT........TIME PRINT FREQUENCY(HOURS)
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C     NPRINT........SPACE PRINT FREQUENCY(ELEMENTS)
C     NTAPE1........TAPE NO  W/ THERMAL AND HYDRAULIC INPUT
C     NTAPE2........TAPE NO. W/ UPSTREAM INFLOW CONCENTRATIONS
C     NTAPE3........TAPE NO  FOR QUALITY SIMULATION OUTPUT
C        (8I5)
      READ (NDRUM1,680) IDAY,LDAY,LOGIC,IPRINT,NPRINT,NTAPE1,NTAPE2,NTAP
     1E3
      IF (NTAPE1 LE 0) NTAPE1-4
      DAYS-FLOAT(IDAY)
C
      WRITE (6,730) IDAY,LDAY,LOGIC,IPRINT,NPRINT,NTAPE1,NTAPE2,NTAPE3
C
C        CARD 4
C     NELEM1........NUMBER OF ELEMENTS IN THE UPSTREAM SEGMENT
C     NADA..........DUMMY VARIABLE (BLANK)
C     DIFUSY........EFFECTIVE DIFFUSION CONSTANT (M.**2/SEC )
C     DELTH.........SIMULATION TIME STEP (HOURS)
C     DELZ..........STANDARD ELEMENT THICKNESS (M. )
C     DEPTH.........LIGHT EXTINCTION DEPTH-SECCHI DISK READING (M. )
C        (2I5,4F10.0)
      READ (NDRUM1,690) NELEM1,NADA,DIFUSY,DELTH,DELZ,DEPTH
      WRITE (6,740) NSEG,NELEM1,DIFUSY,DELTH,DELZ,DEPTH
      IF ((NSEG.LE.0.OR.NSEG GT NN) OR.(NELEM1 LE.0 OR.NELEM1.GT NN)) ST
     1OP
      IF (DIFUSY LE 0  OR DELZ LE 0..OR.DELTH.LE.0..OR.DEPTH.LT.0.) STOP
     1 0
      IF (LOGIC GT 0) GO TO 470
C
C     READ THE MODEL SELECTION
C
C        CARD 5
C     MODALG.....   ALGAE MODELS (2)
C     MODBOD....    B.O.D. MODELS (2)
C     MODDOX........DISSOLVED OXYGEN MODELS (3)
C     MODTIN........NITROGEN MODELS (2)
C     MODPHO.....   PHOSPHOROUS MODELS (3)
C        (5I5)
      READ (NDRUM1,680) MODALG,MODBOD,MODDOX,MODTIN,MODPHO
C        SET THE DEFAULT MODELS
      IF ((MODALG.LT. 1). OR. (MODALG. GT. 2)) MODALG-2
      IF ((MODBOD. LT. 1). OR. (MODBOD. GT. 2)) MODBOD-2
      IF ((MODDOX. LT. 1). OR. (MODDOX. GT. 3)) MODDOX-3
      IF ((MODTIN. LT. 1). OR. (MODTIN. GT. 2)) MODTIN=2
      IF ((MODPHO. LT. 1). OR. (MODPHO. GT. 3)) MODPHO=3
C        PRINT THE MODEL SELECTED
      WRITE (6,760)
      GO TO (120,130), MODALG
120   WRITE (6,770) MODALG
      GO TO 140
130   WRITE (6,780) MODALG
C
140   GO TO (150,160), MODBOD
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150   WRITE (6,790) MODBOD
      GO TO 170
160   WRITE (6,800) MODBOD
C
170   GO TO (180,190,200), MODDOX
180   WRITE (6,810) MODDOX
      GO TO 210
190   WRITE (6,820) MODDOX
      GO TO 210
200   WRITE (6,830) MODDOX
C
210   GO TO (220,230), MODTIN
220   WRITE (6,840) MODTIN
      GO TO 240
230   WRITE (6,850) MODTIN
C
240   GO TO (250,260,270), MODPHO
250   WRITE (6,860) MODPHO
      GO TO 280
260   WRITE (6,870) MODPHO
      GO TO 280
270   WRITE (6,880) MODPHO
280   CONTINUE
      WRITE (6,1030)
C
C     READ A SET OF COEFFICIENTS FOR THE WATER QUALITY MODEL.
C     THESE COEFFICIENTS ARE ASSIGNED UNIFORMLY FOR THE
C     ENTIRE RESERVOIR
C
C        CARD 6
C     ID. .........PARAMETER IDENTIFICATION (SEE CARD 7)
C        (2I5)
290   READ (NDRUM1,690) ID
      IF (ID.LE.8) GO TO 300
      WRITE (6,750) ID
      STOP
300   IF (ID.LE.0) GO TO 400
      ISUM=ISUM+ID
      NL=LIMIT(ID)
C
C        CARD 7
C     COEF..........MODEL COEFFICIENTS.
C                   ID CODE  PARAMETER           PARAMETER
C                            CONSTANTS           UNITS
C                     1        ALGAE             (MG./L.)
C                     2        B. O. D.          (MG./L.)
C                     3        BENTHIC B. O. D.  (G. /M**2)
C                     4        PHOSPHOROUS       (MG./L.)
C                     5        NITROGEN          (MG./L.)
C                     6        SUSPENDED ALGAE   (MG./L.)
C                     7        T. O. C.          (MG./L.)
C                     8        TOXIC COMPOUNDS   (MG./L.)
C
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```
C       (7E10.0)
      READ (NDRUM1,620) (COEF(1,K),K=1,NL)
      GO TO (310,320,330,340,390,430,440,450), ID
C       ALGAE CONSTANTS
310   CALL LOAD (ID,NSEG,NL,COEF,ALGIN)
      WRITE (6,990) ID
      WRITE (6,1000) (ALGIN(1,K),K-1,NL)
      GO TO 290
C       B.O.D.  CONSTANTS
320   CALL LOAD (ID,NSEG,NL,COEF,BODIN)
      WRITE (6,890) ID
      WRITE (6,1000) (BODIN(1,K),K=1,NL)
      GO TO 290
C       BENTHIC CONSTANTS
330   CALL LOAD (ID,NSEG,NL,COEF,BENIN)
      WRITE (6,900) ID
      WRITE (6,1000) (BENIN(1,K),K-1,NL)
      GO TO 290
C       PHOSPHUROUS CONSTANTS
340   CALL LOAD (ID,NSEG,NL,COEF,PHOIN)
      GO TO (350,360,370), MODPHO
350   WRITE (6,940) ID
      GO TO 380
360   WRITE (6,950) ID
      GO TO 380
370   WRITE (6,960) ID
380   WRITE (6,1000) (PHOIN(1,K),K=1,NL)
      GO TO 290
C       NITROGEN CONSTANTS
390   CALL LOAD (ID,NSEG,NL,COEF,TININ)
      GO TO (400,410), MODTIN
400   WRITE (6,970) ID
      GO TO 420
410   WRITE (6,980) ID
420   WRITE (6,1000) (TININ(1,K),K-1,NL)
      GO TO 290
C       SUSPENDED ALGAE CONSTANTS
430   CALL LOAD (ID,NSEG,NL,COEF,SPRIN)
      WRITE (6,930) ID
      WRITE (6,1000) (SPRIN(1,K),K=1,NL)
      GO TO 290
C       ORGANIC CARBON CONSTANTS
440   CALL LOAD (ID,NSEG,NL,COEF,TOCIN)
      WRITE (6,910) ID
      WRITE (6,1000) (TOCIN(1,K),K=1,NL)
      GO TO 290
C       TOXIC CONSTANTS
450   CALL LOAD (ID,NSEG,NL,COEF,TOXIN)
      WRITE (6,920) ID
      WRITE (6,1000) (TOXIN(1,K),K=1,NL)
      GO TO 290
460   IF (ISUM.EQ.JSUM) GO TO 470
```

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      WRITE (6,750)
      STOP
470   CONTINUE
C
C        INITIAL CONDITIONS
C
C     READ A SET OF INITIAL CONDITIONS FOR THE SEGMENT BEGINNING WITH
C     THE BOTTOM ELEMENT.  ELEMENTS IN EACH SEGMENT ARE INDEXED FROM
C     THE RESERVOIR BOTTOM TO THE WATER SURFACE. AND THE INITAL CONDI-
C     TIONS MUST BE LOADED IN A SIMILAR ORDER. THE PARAMETER UNITS ARE
C     SUMMARIZED ON CARD 7
C
C        CARD 8
C     SWITCH      . A SENTRY FOR SELECTING THE MODE OF INPUT
C                     SWITCH<0 --> CONSTANT (NO VERTICAL VARIATION FOR
C                                  THE K-TH PARAMETER)
C                     SWITCH=0 --> VARIABLE
C     CONC. . . . . . PARAMETER VALUE (SWITCH< 0)
C     C(J,K). . . . . PARAMETER VALUES (SWITCH=0)
C
      DO 520 I=1,NSEG
      DO 510 K=1,MAXCON
C
C        CARD 8 - SWITCH<0
C        (I5,E10.0)
      READ (NDRUM1,1020) SWITCH,CONC
      IF (SWITCH) 480,500,500
480   DO 490 J=1,NELEM1
490   C(J,K)=CONC
      GO TO 510
C
C        CARD 8 - SWITCH=0
C        (8E10.0)
500   READ (NDRUM1,1010) (C(J,K),J=1,NELEM1)
510   CONTINUE
      CALL ZERO (2,MM,1,2,C)
      CALL ZERO (NELEM1+1,MM,1,MAXCON,C)
      WRITE (NDRUM3) ((C(J,K),K=1,MAXCON),J=1,MM)
520   CALL PRINTS (I,NPRIN),DAYS,0.0,NELEM1,C,1)
C
C        UPSTREAM INFLOW CONDITIONS
C     READ A SET OF UPSTREAM INFLOW CONCENTRATIONS(BOUNDARY CONDITIONS).
C     IT IS ASSUMED THAT THE UPSTREAM INFLOW OR SOME TRIBUTARY INFLOW IS
C     THE NATURAL SOURCE OF POLLUTANTS.  HOWEVER, THE TRANSPORT EQNS.
C     ARE PROGRAMMED WITH SOURCE TERMS.  THE SOURCE VARIABLE 'SORCE(J,K)'
C     IS PRESENTLY SET TO ZERO.
C
C        CARD 9
C     LOWEST........LOWEST ELEMENT WITH UPSTREAM INFLOW
C        (I5)
      READ (NDRUM1,1020) LOWEST
      IF (LOWEST.LT.0.OR.LOWEST.GT.MM) STOP
      IF (NTAPE2.GT.0) GO TO 550
      DO 540 K=3,MAXCON
C
C        CARD 10
C     CONC..........CONSTANT VALUE FOR K-TH PARAMETER
C        (E10.0)
      READ (NDRUM1,1010) CONC
      DO 530 J=1,MM
530   CCIN(J,K)=CONC
540   CONTINUE
      CALL ZERO (1,LOWEST,1,MAXCON,CCIN)
      CALL PRINTS (1,NPRINT,DAYS,0.0,NELEM1,CCIN,2)
550   DO 580 II=IDAY,LDAY
      IF (NTAPE2.LE.0) GO TO 570
      READ (NTAPE2) (CCIN(MM,K),K=3,MAXCON)
      CALL ZERO (1,LOWEST,1,MAXCON,CCIN)
      DO 560 J=LOWEST,MM
      DO 560 K=3,MAXCON
560   CCIN(J,K)=CCIN(MM,K)
570   WRITE (NDRUM4) ((CCIN(J,K),K=3,MAXCON),J=1,MM)
580   CONTINUE
C
C        SORCES
      CALL ZERO (1,MM,1,MAXCON,SORCE)
C
C        TRIBUTARY INFLOW CONCENTRATIONS
C     READ THE TRIBUTARY INFLOW CONCENTRATIONS FOR EACH SEGMENT
C     TRIBUTARY INFLOWS ARE ASSUMED CONSTANT
C
C        CARD 11
C     NRD..........NUMBER OF SEGMENTS W/ TRIBUTARY INFLOWS
C     NTRIBS.......SEGMENT NUMBERS W/ TRIBUTARY INFLOWS
C        (16I5)
      READ (NDRUM1,680) NRD,(NTRIBS(N),N=1,NRD)
      IF (NRD.GT.0) GO TO 590
      CALL ZERO (1,MAXCON,1,1,CTRIB)
      GO TO 600
C
C        CARD 12
C     CTRIB.........TRIBUTARY INFLOW CONCENTRATIONS
C        (7E10.0)
590   READ (NDRUM1,620) (CTRIB(K),K=3,MAXCON)
600   CALL QUALTY (IDAY,LDAY,DELTH,NSEG,NELEM1,DELZ,CTRIB,DIFUSY)
610   STOP
C
620   FORMAT (7E10.0)
630   FORMAT (1H1,//,30X,'RESERVOIR SIMULATION PROGRAM'/35X,'BATTELLE-NO
     1RTHWEST'/28X,'WATER RESOURCES SYSTEMS SECTION'/27X,'P. O. BOX 999,
     2RICHLAND WASHINGTON'//30X,28(1H*)/30X,'*  INPUT DATA CARD IMAGES
     3*'/30X,28(1H*)//)
640   FORMAT (35X,'INPUT CARD COLUMNS'/7X,'*  1-10  *  11-20  *  21-30
     1*  31-40  *  41-50  *  51-60  *  61-70  *  71-80  *')
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650   FORMAT (7X,80H1234567890123456789012345678901234567890123456789012
     1345678901234567890123456789O//)
660   FORMAT (16A5)
670   FORMAT (I5,2X,16A5)
680   FORMAT (16I5)
690   FORMAT (2I5,7E10 0)
700   FORMAT (1H1,//,30X,'RESERVOIR SIMULATION PROGRAM'/35X,'BATTELLE-NO
     2RICHLAND WASHINGTON'//30X,28(1H*)/30X,'*    QUALITY SIMULATION
     1RTHWEST'/28X,'WATER RESOURCES SYSTEMS SECTION'/27X,'P.O. BOX 999,
     3*'/30X,28(1H*)//)
710   FORMAT (1H0,20X,16A5/20X,16A5)
720   FORMAT (1H0,28X,'PROBLEM SPECIFICATIONS'/28X,24(1H-))
730   FORMAT (1H0,19X,'FIRST DAY',21(1H.),I10/20X,'FINAL DAY',21(1H.),I1
     10/20X,'LOGIC',25(1H.),I10/20X,'PRINT FREQUENCY (HOURS)',7(1H.),I10
     2/20X,'PRINT FREQUENCY (ELEMENTS)',4(1H.),I10/20X,'INPUT TAPE 1',18
     3(1H.),I10/20X,'INPUT TAPE 2',18(1H.),I10/20X,'OUTPUT TAPE',19(1H.)
     4,I10)
740   FORMAT (1H0,19X,'NUMBER OF SEGMENTS',12(1H.),I10/20X,'NUMBER ELEME
     1NTS IN SEG 1',6(1H.),I10/20X,'EFFECTIVE DIFFUSION CONST',5(1H.),F1
     20.4/20X,'TIME STEP (HOURS)',13(1H.),F10.4/20X,'STANDARD ELEMENT TH
     3ICKNESS....',F10.4/20X,'LIGHT EXTINCTION DEPTH',8(1H.),F10.4)
750   FORMAT (/,20X,'INPUT ERROR-CHECK CARD 6',2I5,//)
760   FORMAT (///,20X,'     MODEL SELECTION     '/20X,24(1H-)/)
770   FORMAT (20X,I3,2X,'ALGAE WILL BE MODELED')
780   FORMAT (20X,I3,2X,'ALGAE WILL NOT BE MODELED')
790   FORMAT (20X,I3,2X,'BOTH CARBONACEOUS AND NITROGENOUS BOD ARE MODEL
     1ED')
800   FORMAT (20X,I3,2X,'TOTAL BOD IS MODELED')
810   FORMAT (20X,I3,2X,'P-R IS PROPORTIONAL TO PHYTOPLANKTON CONCENTRAT
     1ION')
820   FORMAT (20X,I3,2X,'P-R IS NOT PROPORTIONAL TO PHYTOPLANKTON CONCEN
     1TRATION')
830   FORMAT (20X,I3,2X,'NO P-R EFFECTS ARE TO BE CONSIDERED')
840   FORMAT (20X,I3,2X,'THE ALGAL NITROGEN MODEL WILL BE USED')
850   FORMAT (20X,I3,2X,'ONLY THE AMMONIA NITRATE MODEL WILL BE USED')
860   FORMAT (20X,I3,2X,'THE ALGAL PHOSPHOROUS MODEL WILL BE USED')
870   FORMAT (20X,I3,2X,'THE PHOSPHOROUS MODEL IS A FIRST ORDER DECAY MO
     1DEL')
880   FORMAT (20X,I3,2X,'THE PHOSPHOROUS MODEL IS A SECOND ORDER DECAY M
     1ODEL')
890   FORMAT (1H0,I3,2X,'BOD MODEL CONSTANTS'//60(1H-),/' -      CARBONA
     1CEOUS',16X,'NITROGENOUS',10X'-',/' - DECAY   SEDIMENT   SCOUR
     2 TEMP       DECAY     TEMP -',/' - /DAY        /DAY    MG/L/DAY
     3COEFF',7X,'/DAY      COEFF -',/60(1H-))
900   FORMAT (1H0,I3,2X,'BENTHIC MODEL CONSTANTS'//20(1H-),/' - DECAY
     1  TEMP  -',/' - /DAY       COEFF  -',/20(1H-))
910   FORMAT (1H0,I3,2X,'TOC MODEL CONSTANTS'//60(1H-),/' - DECAY   SEDI
     1MENT    PROPR    BIOLOG    REFRAC      TEMP   -',/' - /DAY      /DA
     2Y      COEFF    SCOUR     SCOUR      COEFF  -',/60(1H-))
920   FORMAT (1H0,I3,2X,'TOXIC MODEL CONSTANTS'//30(1H-),/' - DECAY
     1POWER     TEMP  -',/' - CONST      COEFF',11X,'-',/30(1H-))
930   FORMAT (1H0,I3,2X,'P-R FOR SUSPENDED ALGAE'//51(1H-),/' - CONST1
     1  PERIOD     PHASE    CONST2     PHASE -',/' - ',20X,'ANGLE1',14X,'
     2ANGLE2 -'/51(1H-))
 940  FORMAT (1H0,I3,2X,'PHOSPHORUS RATE CONSTANTS'//30(1H-),/' -SOL TO
     1   SED TO     ORG TO -',/' - SED        SOL        SOL   -',/30(1H-))
 950  FORMAT (1H0,I3,2X,'PHOSPHORUS RATE CONSTANTS'//20(1H-),/' -SOL TO
     1   SED TO -',/' - SED        SOL   -',/20(1H-))
 960  FORMAT (1H0,I3,2X,'PHOSPHORUS RATE CONSTANTS'//30(1H-),/' - SOL
     1   SED TO     ORG TO -',/' - DECAY       SOL        SOL  -',/50(1H-))
 970  FORMAT (1H0,I3,2X,' NITROGEN RATE CONSTANTS '//30(1H-),/' -NH3 TO
     1   NO2 TO     ORG TO -',/' - NO2         NO3        NH3   -',/30(1H-))
 980  FORMAT (1H0,I3,2X,' NITROGEN RATE CONSTANTS',//30(1H-),/' -NH3 TO
     1   NO2 TO     ORG TO -',/' - NO3         NO3        NH3   -',/30(1H-))
 990  FORMAT (1H0,I3,2X,'ALGAE MODEL CONSTANTS'//86(1H-),/' - PHYTO',5X,
     1'PHOTO',4X,'EXTINC',4X,'SAT SUM',3X,'AVE SUM',3X,'NTOTAL',7X,'PO4'
     2,6X,'PHYTO-'/' -GROWTH',4X,'PERIOD',5X,'COEFF',3X,'INTENSITY',2X,'
     3INTENSITY',3X,'CONST',5X,'CONST',5X,'DEATH',11X,'-',/90(1H-)/' -
     4ZOO',4X,'CONVERS',5X,'PHYTO',6X,'ZOO',7X,'ZOO',5X,'NIT-PHY',3X,'PH
     5O-PHY',3X,'NIT-ZOO',3X,'PHO-ZOO-',/' - ',49X,'RATIO',5X'RATIO',5X,
     6'RATIO',5X,'RATIO  -',/90(1H-))
1000  FORMAT (8F10.4/9F10.4)
1010  FORMAT (8E10.4)
1020  FORMAT (I5,7E10.0)
1030  FORMAT (1H1,///,25X,'MODEL CONSTANTS',//)
      END
      SUBROUTINE QUALITY (IDAY,LDAY,DELTH,NSEG,NELEM,DELZ,CTRIB,DIFUSY)
C
C     THIS ROUTINE SOLVES THE WATER QUALITY REACTION EQUATIONS AND MASS
C     TRANSPORT EQUATIONS.  THE W.Q. REACTION EQNS. ARE SOLVED  BY A
C     4-TH ORDER RUNGE KUTTA TECHNIQUE AND THE MASS TRANSPORT EQNS. ARE
C     SOLVED BY AN IMPLICIT ALGORITHM FOR SECOND ORDER,LINEAR, PARABOLIC
C     PARTIAL DIFFERENTIAL EQUATIONS.   THREE MAIN LOOPS ARE PROGRAMMED.
C       (1) SEGMENT LOOP(1 THRU N SEGMENTS), (2) TIME LOOP(1 THRU N TIME
C       STEPS) AND (3) ELEMENT LOOP (1 THRU N ELEMENTS).  THIS VERSION
C     IS PROGRAMMED FOR A SINGLE SEGMENT AND UP TO 200 ELEMENTS.
C
      COMMON/BLK1/I,J       I=SEGMENT, J =ELEMENT  (INDICES)
      COMMON/BLK2/MODALG,MODBOD,MODDOX,MODTIN,MODPHO
      COMMON/BLK3/ALGIN,BENIN,BODIN,PHOIN,SPRIN,TOCIN,TOXIN,TININ
      COMMON/BLK4/ALGCAL,BENCAL,BODCAL,DOXCAL,REACAL,SPRCAL,TOCCAL,
     1           TOXCAL
      COMMON/BLK5/AREA,QHIN,QHOUT,QV,DELZT
      COMMON/BLK6/IZRCON
      COMMON/BLK7/HOURS
      COMMON/BLK8/DEPTH,TEMPR
      COMMON/BLK9/NOLITE
      COMMON/BLK10/IPRINT,NPRINT,NTAPE1,NTAPE2,NTAPE3,TITLE,LOGIC
      COMMON/BLK11/SORCE,NTRIBS
C
      DIMENSION AREA(202),QHIN(202),QHOUT(202),QV(202),TEMP(202)
      DIMENSION ALGCAL(6),BENCAL(2),BODCAL(2),DOXCAL(2),
     1          SPRCAL(2),TOCCAL(2),TOXCAL(2)
      DIMENSION ALGIN(1,17),BENIN(1,2),BODIN(1,6),PHOIN(1,3),
     1          SPRIN(1,5),TOCIN(1,6),TOXIN(1,3),TININ(1,3)
      DIMENSION C(202,16),CCIN(202,16),SORCE(202,16)
      DIMENSION YO(16),Y(16)
      DIMENSION IZRCON(16)
      DIMENSION TITLE(32),CTRIB(16),QTRIB(365),NTRIBS(5)
      EQUIVALENCE (DELTD,TF)
C
      DATA A1/14.652/,A2/0.41022/,A3/0.007991/,A4/0.000077774/
      DATA NDRUM1/1/,NDRUM2/2/,NDRUM3/3/,NDRUM4/20/
      DATA MML,MM,NN,MAXCON/203,202,1,16/
C
      REWIND NTAPE1
      REWIND NDRUM3
      REWIND NDRUM4
      IF (NTAPE2.GT.0) REWIND NTAPE2
      IF (NTAPE3.GT.0) REWIND NTAPE3
      IF (NTAPE3.GT.0) WRITE (NTAPE3) (TITLE(IX),IX=1,32),IDAY,LDAY,DELT
     1H,NSEG,DELZ,MODALG,MODBOD,MODDOX,MODTIN,MODPHO
C
C     ...SEGMENT LOOP: CALCULATE QUALITY FOR THE RESERVOIR SEGMENT...
C
      IJK=1
      I=IJK
      DO 100 K=1,MAXCON
100   IZRCON(K)=1
      TO=0.0
      HOURS=0.0
      DAYS=1.0
      DELTD=DELTH/24.
      IZRCHK=1
      NSTEP=IFIX(FLOAT(LDAY-IDAY+1)/DELTD)
      NOLITE=IFIX((FLOAT(NELEM)+DELZ-DEPTH)/DELZ)
      IF (NTAPE3.GT.0) WRITE (NTAPE3) IDAY,LDAY,IJK
      REWIND NDRUM2
      READ (NDRUM3) ((C(J,K),K=1,MAXCON),J=1,MM)
C
C        READ THERMAL AND HYDRAULIC DATA
C
      READ (NTAPE1) IIDAY,LLDAY,NELEM,NXEQ
      IF (NELEM.GT.MM) WRITE (6,240) NELEM
      IF (NELEM.GT.MM) STOP
      IF ((IDAY.LT.IIDAY).OR.(LDAY.GT.LLDAY)) WRITE (6,230) IDAY,IIDAY,L
     1DAY,LLDAY
      IF ((IDAY.LT.IIDAY).OR.(LDAY.GT.LLDAY)) STOP
      READ (NTAPE1) (AREA(J),J=1,NELEM)
      IF (NTRIBS(IJK).GT.0) READ (NTAPE1) IK,JK,(QTRIB(IQ),IQ=IK,JK)
      NXEQ=24/NXEQ
C
C     ...TIME LOOP: CALCULATE QUALITY HISTORIES FOR THE SIMULATION...
C
      DO 220 JKI=1,NSTEP
      HOURS=HOURS+DELTH
C
      IF ((JKI/NXEQ*NXEQ.NE.JKI).AND.(JKI.NE.1)) GO TO 120
      READ (NTAPE1) NELEM,DELZT,WIND
      READ (NTAPE1) (QHIN(J),J=1,NELEM)
      READ (NTAPE1) (QHOUT(J),J=1,NELEM)
      READ (NTAPE1) (TEMP(J),J=1,NELEM)
C        COMPUTE THE VERTICAL FLOWS
      QVIN=0.0
      DO 110 J=1,NELEM
      QV(J)=QHIN(J)+QVIN-QHOUT(J)
      QVIN=QV(J)
110   CONTINUE
C
C        READ THE UPSTREAM FILE FOR THIS SEGMENT.
C
120   IF (((JKI-1)/24*24.NE.(JKI-1)).AND.(JKI.NE.1)) GO TO 130
      READ (NDRUM4) ((CCIN(M,K),K=3,MAXCON),M=1,MM)
C
C     AVERAGE THE INFLOWS TO THE SEGMENT
C
130   IF (NTRIBS(I).GT.0) CALL AVERGE (NELEM,CTRIB,CCIN,QTRIB(JKI),QHIN)
      IF (LOGIC.GT.0) GO TO 190
C
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C     ...ELEMENT LOOP: CALCULATE EQUILIBRIUM CONC. FOR EACH ELEMENT...
C
      DO 180 J=1,NELEM
C
C        CALCULATE THE D.O. SATURATION VALUE
      DOXCAL(1)=A1-A2*TEMP(J)+A3*TEMP(J)**2-A4*TEMP(J)**3
C
C        CALCULATE REAERATION
      CALL REARTN (J,NELEM,WIND,REACAL)
C
C        TEMPERATURE CORRECTIONS
      TEMPR=TEMP(J)
      CALL TEMPER (TEMPR)
C
C        INITIALIZE
      DO 140 K=1,MAXCON
      Y(K)=0.
140   YO(K)=C(J,K)
      YO(1)=YO(1)/(DELZ)
C
C        SOLVE THE WATER QUALITY EQUATIONS.
C
150   CALL DIFEQ (TO,TF,YO,Y,MAXCON)
C        CHECK IF ANY CONCENTRATIONS ARE LESS THAN ZERO. IF TEST IS
C        AFFIRMATIVE, SET THE APPROPRIATE QUALITY PARAMETER TO ZERO
C        AND RESOLVE THE EQUATIONS.
      IZRCHK=1
      DO 160 K=1,MAXCON
      IF (Y(K).GE.0.0) GO TO 160
      YO(K)=0.0
      IZRCON(K)=-1
      IZRCHK=-1
160   CONTINUE
      IF (IZRCHK.LT.0) GO TO 150
C
      Y(1)=Y(1)*DELZ
      DO 170 K=1,MAXCON
      IZRCON(K)=1
170   C(J,K)=Y(K)
180   CONTINUE
C
C        SOLVE THE TRANSPORT EQUATION FOR EACH CONSTITUENT
C
190   CALL TRANSP (DELTH*3600.,NELEM,DIFUSY,DELZ,CCIN,SORCE,C)
      IF ((JKI/IPRINT*IPRINT.NE.JKI).AND.(JKI.NE.1)) GO TO 200
C
C        PRINT THE RESULTS IF REQUESTED.
C
      CALL PRINTS (IJK,NPRINT,DAYS,HOURS,NELEM,C,3)
200   CONTINUE
C
C        WRITE THE SIMULATION RESULTS TO TAPE IF REQUESTED.
```

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C
      IF (NTAPE3.LE.0) GO TO 210
      WRITE (NTAPE3) JKI,(((C(JJ,KK),KK=1,MAXCON),TEMP(JJ),JJ=1,NELEM)
C
210   IF (HOURS.LT.24.) GO TO 220
      HOURS=0.0
      DAYS=DAYS+1.0
220   CONTINUE
C
      STOP
C
230   FORMAT (/,5X,'TAPE INPUT IS NOT CONSISTENT WITH THE PROBLEM SPECIF
     1ICATION',/,5X,'IDAY',I5,'IIDAY',I5,/,5X,'LDAY',I5,'LLDAY',I5,/)
240   FORMAT (//,5X,'NUMBER OF ELEMENTS EXCEEDS PRESENT LIMIT',I5)
      END
      SUBROUTINE TRANSP (DELT,M,DIFUSY,DZ,CCIN,SORCE,CONC)
C
C     THE MASS TRANSPORT EQUATION IS SOLVED BY AN IMPLICIT METHOD
C
      COMMON/BLK5/AREA,QHIN,QHOUT,QV,DZT
      DIMENSION A(202),B(202),C(202),D(202),CCC(202)
      DIMENSION CONC(202,16),CCIN(202,16),SORCE(202,16)
      DIMENSION AREA(202),QHIN(202),QHOUT(202),QV(202)
      DATA MAXCON/16/
C
C        PERFORM CALCULATIONS OVER THE TIME STEP DELT.
C
      DO 110 J=3,MAXCON
      DO 100 I=1,M
C
C        SET THE COEFFICIENT ARRARYS A,B,C AND COMPUTE THE RIGHT-HAND
C        VECTOR D.
C
      IF (I NE M) DY=DZ
      IF (I EQ M) DY=(DZT+DY)/2
      RATIO=DELT/(DY*DY)
      A(I)=-RATIO*DIFUSY
      B(I)=1.0+2.0*RATIO*DIFUSY-QV(I)*DY*RATIO/AREA(I)
      C(I)=QV(I+1)*RATIO*DY/AREA(I)-RATIO*DIFUSY
      D(I)=(1.-QHOUT(I)*DY*RATIO/AREA(I))*CONC(I,J)+QHIN(I)*DY*RATIO/ARE
     1A(I)*CCIN(I,J)+SORCE(I,J)*RATIO*DY/AREA(I)
100   CCC(I)=CONC(I,J)
C
C        SET BOUNDARY CONDITIONS
C
      CALL BNDRYS (J,M,A,B,C,D,DZ,DELT,CONC,CCIN)
C
C        SOLVE THE SYSTEM OF EQUATIONS
C
      CALL TRIDAG (1,M,A,B,C,D,CCC)
      DO 110 I=1,M
110   CONC(I,J)=CCC(I)
C
      RETURN
      END
      SUBROUTINE TRIDAG (IF,L,A,B,C,D,V)
C
C     SUBROUTINE FOR SOLVING A SYSTEM OF LINEAR SIMULTANEOUS
C     EQUATIONS OF THE TRIDIAGONAL FORM.
C     THE EQUATIONS ARE NUMBERED FROM IF THROUGH L, AND THEIR
C     SUB-DIAGONAL, DIAGONAL, AND SUPER-DIAGONAL COEFFICIENTS
C     ARE STORED IN THE ARRAYS A, B, AND C.  THE COMPUTED
C     SOLUTION VECTOR V(IF),...,V(L) IS STORED IN THE ARRAY V
C
      DIMENSION A(1),B(1),C(1),D(1),V(1),BETA(202),GAMMA(202)
C
C        COMPUTE THE INTERMEDIATE ARRAYS BETA AND GAMMA
C
      BETA(IF)=B(IF)
      GAMMA(IF)=D(IF)/BETA(IF)
      IFP1=IF+1
      DO 100 I=IFP1,L
      BETA(I)=B(I)-A(I)*C(I-1)/BETA(I-1)
100   GAMMA(I)=(D(I)-A(I)*GAMMA(I-1))/BETA(I)
C
C        COMPUTE FINAL SOLUTION VECTOR V
C
      V(L)=GAMMA(L)
      LAST=L-IF
      DO 110 K=1,LAST
      I=L-K
110   V(I)=GAMMA(I)-C(I)*V(I+1)/BETA(I)
C
      RETURN
      END
      SUBROUTINE BNDRYS (K,M,A,B,C,D,DZ,DELT,CONC,CCIN)
C
C     THIS ROUTINE ESTABLISHES THE BOUNDAY CONDITIONS OF EACH
C     CONSTITUENT: K=3,4, ...,16, FOR THE BOTTOM AND UPPERMOST ELEMENTS
C
      COMMON/BLKS/AREA,QHIN,QHOUT,QV,DZT
      DIMENSION A(1),B(1),C(1),D(1),CONC(202,16),CCIN(202,16)
      DIMENSION AREA(202),QHIN(202),QHOUT(202),QV(202)
      DATA MAXCON/16/
C
C        BOTTOM ELEMENT
C
      B(1)=B(1)+A(1)
      A(1)=0.0
C
C        TOP ELEMENT
C
      B(M)=B(M)+C(M)
      C(M)=0.0
C
      RETURN
      END
      SUBROUTINE DIFEQ (X,XE,Y,YF,NN)
C
C     THIS ROUTINE EMPLOYS THE FOURTH-ORDER RUNGE-KUTTA METHOD
C     WITH RUNGE'S COEFFICIENTS TO INTEGRATE A SYSTEM OF N
C     SIMULTANEOUS FIRST ORDER ORDINARY DIFFERENTIAL EQUATIONS :
C             DY/DT = F(Y,T)
C
      DIMENSION Y(16),YI(16),YF(16)
      DIMENSION AM1(16),AM2(16),AM3(16),AM4(16)
      I=3
      XF=X
      FI=I
      H=(XE-XF)/FI
      N=NN
      DO 100 J=1,N
100   YF(J)=Y(J)
      DO 140 J=1,I
      CALL DE (XF,YF,AM1)
      XF=XF+H/2.0
      DO 110 K=1,N
110   YI(K)=YF(K)+AM1(K)*H/2.0
      CALL DE (XF,YI,AM2)
      DO 120 K=1,N
120   YI(K)=YF(K)+AM2(K)*H/2.0
      CALL DE (XF,YI,AM3)
      XF=XF+H/2.0
      DO 130 K=1,N
130   YI(K)=YF(K)+AM3(K)*H
      CALL DE (XF,YI,AM4)
      DO 140 K=1,N
140   YF(K)=H/6.0*(AM1(K)+AM4(K)+2.0*(AM2(K)+AM3(K)))+YF(K)
C
      RETURN
      END
      SUBROUTINE DE (T,Y,F)
C
C     THIS ROUTINE EVALUATES THE DERIVATIVES FOR THE NUMERICAL
C     INTEGRATION ROUTINE DIFEQ.
C     LEGEND:
C        Y(I).........QUALITY PARAMETERS
C           1         BENTHIC B. O. D.
C           2         SEDIMENTARY PHOSPHOROUS
C           3         SOLUBLE PHOSPHOROUS
C           4         ORGANIC PHOSPHOROUS
C           5         CARBONACEOUS B. O. D.
C           6         NITROGENOUS B. O. D.
C           7         REFRACTORY ORGANIC CARBON
C           8         TOTAL ORGANIC CARBON
C           9         AMMONIA NITROGEN
C          10         NITRITE NITROGEN
C          11         NITRATE NITROGEN
C          12         ORGANIC NITROGEN
C          13         TOXIC COMPOUND
C          14         PHYTOPLANKTON
C          15         ZOO PLANKTON
C          16         DISSOLVED OXYGEN
C
      COMMON/BLK4/ALGCAL,BENCAL,BODCAL,DOXCAL,REACAL,SPRCAL,TOCCAL,
     1            TOXCAL
      COMMON/BLK6/IZRCON
      COMMON/BLK7/HOURS
C
      DIMENSION Y(16),F(16)
      DIMENSION ALGCAL(6),BENCAL(2),BODCAL(2),DOXCAL(2),
     1          SPRCAL(2),TOCCAL(2),TOXCAL(2)
      DIMENSION IZRCON(16)
      DATA MAXCON/16/
      TIME=HOURS/24.
C
C        CALCULATE NITROGEN AND PHOSPHOROUS CONCENTRATIONS FOR USE IN
C        ALG ROUTINE
C
      ALGCAL(5)=Y(9)+Y(11)
      ALGCAL(6)=Y(3)
C
C        CALL SUBROUTINES FOR EVALUATION OF DY/DT = F(Y,T) TERMS.
C        NOTE THAT ALG MUST BE CALLED BEFORE PHO AND TIN AND SPR AND
C        MUST BE CALLED BEFORE DOX.
C
      CALL ALG (Y(14),Y(15),F(14),F(15))
      CALL PHO (Y(3),Y(2),Y(4),Y(14),Y(15),F(3),F(2),F(4))
      CALL TIN (Y(9),Y(10),Y(11),Y(12),Y(14),Y(15),F(9),F(10),F(11),F(12
     1))
      CALL SPR (Y(14),TIME)
      CALL DOX (Y(16),Y(5),Y(6),Y(1),F(16))
      CALL BOD (Y(5),Y(6),F(5),F(6))
      CALL BEN (Y(1),Y(5),F(1))
      CALL TOC (Y(8),Y(7),Y(5),F(8),F(7))
      CALL TOX (Y(13),F(13))
C
      RETURN
      END
      SUBROUTINE ALG (P,Z,DPDT,DZDT)
C
C     THIS SUBROUTINE CALCULATES THE RATE OF CHANGE OF PHYTOPLANKTON AND
C     ZOOPLANKTON BASED ON THE GROWTH AND DEATH RATES PROPOSED BY DITORO
C     , ET. AL., 1970   TWO MODELS ARE AVAILABLE
C
C             MODALG
C               1        ALGAE CALCULATION PERFORMED
C               2        ALGAE CALCULATION NOT PERFORMED
C
C        THE FOLLOWING NOMENCLATURE IS USED
C
C             ALGCAL(1).....PHYTO GROWTH RATE
C             ALGCAL(2).....PHYTO DEATH RATE
C             ALGCAL(3).....ZOO GROWTH RATE
C             ALGCAL(4).....ZOO DEATH RATE
C             ALGCAL(5).....EFFECTIVE NITROGEN CONCENTRATION
C             ALGCAL(6).....EFFECTIVE PHOSPHORUS CONCENTRATION
C             P.............PHYTOPLANKTON CONCENTRATION
C             Z.............ZOOPLANKTON CONCENTRATION
C
      COMMON/BLK1/I,J      I=SEGMENT, J =ELEMENT  (INDICES)
      COMMON/BLK2/MODALG,MODBOD,MODDOX,MODTIN,MODPHO
      COMMON/BLK3/ALGIN,BENIN,BODIN,PHOIN,SPRIN,TOCIN,TOXIN,TININ
      COMMON/BLK4/ALGCAL,BENCAL,BODCAL,DOXCAL,REACAL,SPRCAL,TOCCAL,
     1            TOXCAL
      COMMON/BLK6/IZRCON
      COMMON/BLK8/DTEMP,TEMPR
      COMMON/BLK9/NOLITE
C
      DIMENSION ALGCAL(6),BENCAL(2),BODCAL(2),DOXCAL(2),
     1          SPRCAL(2),TOCCAL(2),TOXCAL(2)
      DIMENSION ALGIN(1,17),BENIN(1,2),BODIN(1,6),PHOIN(1,3),
     1          SPRIN(1,5),TOCIN(1,6),TOXIN(1,3),TININ(1,3)
      DIMENSION IZRCON(16)
C
C        SELECT AN ALGAE MODEL
C
      GO TO (100,110), MODALG
C        CALCULATE PHYTOPLANKTON GROWTH RATE
100   CONTINUE
      COEF1=ALGIN(I,1)*TEMPR*2.718*ALGIN(I,2)/(ALGIN(I,3)*DTEMP)
      COEF2=EXP(-ALGIN(I,4)/ALGIN(I,5)*EXP(-ALGIN(I,3)*DTEMP))-EXP(-ALGI
     1N(I,4)/ALGIN(I,5))
      COEF3=ALGCAL(5)/(ALGIN(I,6)+ALGCAL(5))*ALGCAL(6)/(ALGIN(I,7)+ALGCA
     1L(6))
      IF (J.LT.NOLITE) COEF1=0.0
      ALGCAL(1)=COEF1*COEF2*COEF3
C        CALCULATE PHYTOPLANKTON DEATH RATE
      ALGCAL(2)=ALGIN(I,8)*TEMPR+ALGIN(I,9)*2
C        CALCULATE ZOOPLANKTON GROWTH RATE
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      ALGCAL(3)=ALGIN(I,10)*ALGIN(I,9)*ALGIN(I,11)*P/(P+ALGIN(I,11))
C        CALCULATE ZOOPLANKTON DEATH RATE
      ALGCAL(4)=ALGIN(I,16)*TEMPR+ALGIN(I,17)
C        CALCULATE DERIVATIVES
      DPDT=(ALGCAL(1)-ALGCAL(2))*P
      DZDT=(ALGCAL(3)-ALGCAL(4))*Z
      GO TO 120
C
C        ZERO MODEL
C
110   DPDT=0.
      DZDT=0.
C        CHECK FOR ZERO CONCENTRATIONS
120   IF (IZRCON(14).LT.0) DPDT=0.
      IF (IZRCON(15).LT.0) DZDT=0.
C
      RETURN
      END
      SUBROUTINE PHO (D1,D2,D3,P,Z,DD1DT,DD2DT,DD3DT)
C
C     THIS SUBROUTINE CALCULATES THE RATE OF CHANGE OF THREE
C     COMPONENTS OF PHOSPHORUS BASED ON FIRST ORDER REACTIONS.
C     THE FOLLOWING MODELS ARE AVAILABLE
C
C              MODPHO
C                1        ALGAL PHOSPHORUS MODEL
C                2        FIRST ORDER DECAY MODEL
C                3        SECOND ORDER DECAY MODEL
C
C         THE FOLLOWING NOMENCLATURE IS USED
C
C              PHOIN(I,1).....RATE CONSTANT FROM SOLUBLE  TO SEDIMENT
C              PHOIN(I,2).....RATE CONSTANT FROM SEDIMENT TO SOLUBLE
C              PHOIN(I,3).....RATF CONSTANT FROM ORGANIC TO SOLUBLE
C              D1.............SOLUBLE PHOSPHORUS CONCENTRATION
C              D2.............SEDIMENT PHOSPHORUS CONCENTRATION
C              D3.............ORGANIC PHOSPHORUS CONCENTRATION
C
      COMMON/BLK1/I,J      I=SEGMENT,  J =ELEMENT  (INDICES)
      COMMON/BLK2/MODALG,MODBOD,MODDOX,MODTIN,MODPHO
      COMMON/BLK3/ALGIN,BENIN,BODIN,PHOIN,SPRIN,TOCIN,TOXIN,TININ
      COMMON/BLK4/ALGCAL,BENCAL,BODCAL,DOXCAL,REACAL,SPRCAL,TOCCAL,
     1          TOXCAL
      COMMON/BLK6/IZRCON
C
      DIMENSION ALGCAL(6),BENCAL(2),BODCAL(2),DOXCAL(2),
     1          SPRCAL(2),TOCCAL(2),TOXCAL(2)
      DIMENSION ALGIN(1,17),BENIN(1,2),BODIN(1,6),PHOIN(1,3),
     1          SPRIN(1,5),TOCIN(1,6),TOXIN(1,3),TININ(1,3)
      DIMENSION IZRCON(16)
C
C        SELECT A PHOSPHOROUS MODEL
C
      GO TO (100,130,140), MODPHO
C
C        ALGAL PHOSPHOROUS MODEL
C
C        CHECK D.O. CONCENTRATION
100   IF (IZRCON(16)) 120,120,110
C        D.O. CONCENTRATION IS NOT ZERO
110   DD1DT=-PHOIN(I,1)*D1+PHOIN(I,2)*D2+PHOIN(I,3)*D3-ALGCAL(1)*P*ALGIN
     1(I,13)
      DD2DT=-PHOIN(I,2)*D2+PHOIN(I,1)*D1
      DD3DT=-PHOIN(I,3)*D3+ALGCAL(2)*P*ALGIN(I,13)+(ALGCAL(4)-ALGCAL(3))
     1*Z*ALGIN(I,14)
      GO TO 150
C        D.O. CONCENTRATION IS ZERO
120   DC1DT=-PHOIN(I,1)*D1+PHOIN(I,2)*D2+PHOIN(I,3)*D3-ALGCAL(1)*P*ALGIN
     1(I,13)
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      DD2DT=-PHOIN(I,2)*D2+PHOIN(I,1)*D1
      DD3DT=ALGCAL(2)*P*ALGIN(I,13)+(ALGCAL(4)-ALGCAL(3))*Z*ALGIN(I,14)
      GO TO 150
C
C        FIRST ORDER PHOSPHOROUS MODEL
C
130   DD1DT=-PHOIN(I,1)*D1+PHOIN(I,2)*D2
      DD2DT=-PHOIN(I,2)*D2+PHOIN(I,1)*D1
      DD3DT=0.
      GO TO 150
C
C        SECOND ORDER PHOSPHOROUS MODEL
C
140   DD1DT=-PHOIN(I,1)*D1*D1
      DD2DT=0.
      DD3DT=0.
C        CHECK FOR ZERO CONCENTRATIONS
150   IF (IZRCON(2).LT.0) DD2DT=0.
      IF (IZRCON(3).LT.0) DD1DT=0.
      IF (IZRCON(4).LT.0) DD3DT=0.
C
      RETURN
      END
      SUBROUTINE TIN (C1,C2,C3,C4,P,Z,DC1DT,DC2DT,DC3DT,DC4DT)
C
C     THIS SUBROUTINE CALCULATES THE  RATE OF CHANGE OF FOUR
C     COMPONENTS OF NITROGEN BASED ON FIRST ORDER REACTIONS  THE
C     FOLLOWING MODELS ARE AVAILABLE
C
C             MODTIN
C               1.......ALGAL NITROGEN MODEL
C               2.......AMMONIA - NITRATE ONLY MODEL
C
C         THE FOLLOWING NOMENCLATURE IS USED
C
C             TININ(I,1).....RATE CONSTANT FROM NH3 TO NO2 (MODTIN 1)
C             TININ(I,1).....RATE CONSTANT FROM NH3 TO NO3 (MODTIN 2)
C             TININ(I,2).....RATE CONSTANT FROM NO2 TO NO3
C             TININ(I,3).....RATE CONSTANT FROM ORGANIC-N TO NH3
C             C1.............NH3 CONCENTRATION
C             C2.............NO2 CONCENTRATION
C             C3.............NO3 CONCENTRATION
C             C4.............ORGANIC-N CONCENTRATION
C
      COMMON/BLK1/I,J      I=SEGMENT, J =ELEMENT  (INDICES)
      COMMON/BLK2/MODALG,MODBOD,MODDOX,MODTIN,MODPHU
      COMMON/BLK3/ALGIN,BENIN,BODIN,FHOIN,SPRIN,TOCIN,TOXIN,TININ
      COMMON/BLK4/ALGCAL,BENCAL,BODCAL,DOXCAL,REACON,SPRCAL,TOCCAL,
     1            TOXCAL
      COMMON/BLK6/IZRCON
C
      DIMENSION ALGCAL(6),BENCAL(2),BODCAL(2),DOXCAL(2),
     1          SPRCAL(2),TOCCAL(2),TOXCAL(2)
      DIMENSION ALGIN(1,17),BENIN(1,2),BODIN(1,6),FHOIN(1,3),
     1          SPRIN(1,5),TOCIN(1,6),TOXIN(1,3),TININ(1,3)
      DIMENSION IZRCON(16)
C
C         SELECT A NITROGEN MODEL
C
      GO TO (100,140), MODTIN
C
C         ALGAL NITROGEN MODEL
C
C         CHECK FOR ZERO D.O.  CONCENTRATION
100   CTEMP=C1+C3
      IF (CTEMP.GT.1.E-7) GO TO 110
      CTEMP=1.
110   IF (IZRCON(16)) 130,130,120
C         D.O. CONCENTRATION IS NOT ZERO
120   DC1DT=-TININ(I,1)*C1+TININ(I,3)*C4-ALGCAL(1)*P*ALGIN(I,12)*C1/(CTE
     1MP)
      DC2DT=-TININ(I,2)*C2+TININ(I,1)*C1
      DC3DT=TININ(I,2)*C2-ALGCAL(1)*P*ALGIN(I,12)*C3/(CTEMP)
      DC4DT=-TININ(I,3)*C4+ALGCAL(2)*P*ALGIN(I,12)+(ALGCAL(4)-ALGCAL(3))
     1+Z*ALGIN(I,15)
      GO TO 170
C        D.O. CONCENTRATION IS ZERO
130   DC1DT=-ALGCAL(1)*P*ALGIN(I,12)*C1/(C1+C3)
      DC2DT=0.
      DC3DT=-ALGCAL(1)*P*ALGIN(I,12)*C3/(C1+C3)
      DC4DT=ALGCAL(2)*P*ALGIN(I,12)+(ALGCAL(4)-ALGCAL(3))*Z*ALGIN(I,15)
      GO TO 170
C
C        AMMONIA-NITRATE MODEL
C
C        CHECK D.O. FOR ZERO CONCENTRATION
140   IF (IZRCON(16)) 160,160,150
C        D.O. CONCENTRATION IS NOT ZERO
150   DC1DT=-TININ(I,2)*C1
      DC2DT=0.
      DC3DT=+TININ(I,2)*C1
      DC4DT=0.
      GO TO 170
C        D.O. CONCENTRATION IS ZERO
160   DC1DT=0.0
      DC2DT=0.0
      DC3DT=0.0
      DC4DT=0.0
C        CHECK FOR ZERO CONCENTRATIONS
170   IF (IZRCON(9).LT.0) DC1DT=0.
      IF (IZRCON(10).LT.0) DC2DT=0.
      IF (IZRCON(11).LT.0) DC3DT=0.
      IF (IZRCON(12).LT.0) DC4DT=0.
C
      RETURN
      END
      SUBROUTINE SPR (P,T)
C
C     THIS SUBROUTINE CALCULATES THE DO PRODUCTION OR USE RHTE DUE
C     TO SUSPENDED PHYTOPLANKTON  THREE MODELS ARE AVAILABLE
C
C              MODDOX
C                1       RATE IS PROPORTIONAL TO PHYTOPLANKTON DENSITY
C                2       RATF IS INDEPENDENT OF PHYTOPLANKTON DENSITY
C                3       RHTE IS ZERO
C
C         THE FOLLOWING NOHENCLATURE IS USED
C
C              SPRIN(I,1).....FIRST TERM CONSTANT
C              SPRIN(I,2).....PERIOD
C              SPRIN(I,3).....FIRST TERM PHASE ANGLE
C              SPRIN(I,4).....SECOND TERM CONSTANT
C              SPRIN(I,5).....SFCUND TERM  PHASE ANGLE
C
      COMMON/BLK1/I,J      I=SFGMENT, J =ELEMENT  (INDICES)
      COMMON/BLK2/MODALG,MODBOD,MODDOX,MODTIN,MODPHO
      COMMON/BLK3/ALGIN,BENIN,BODIN,PHOIN,SPRIN,TOCIN,TOXIN,TININ
      COMMON/BLK4/ALGCAL,BENCAL,BODCAL,DOXCAL,REACAL,SPRCAL,TOCCAL,
     1            TOXCAL
      COMMON/BLK6/IZRCON
C
      DIMENSION ALGCAL(6),BENCAL(2),BODCAL(2),DOXCAL(2),
     1          SPRCAL(2),TOCCAL(2),TOXCAL(2)
      DIMENSION ALGIN(1,17),BENIN(1,2),BODIN(1,6),PHOIN(1,3),
     1          SPRIN(1,5),TOCIN(1,6),TOXIN(1,3),TININ(1,3)
      DIMENSION IZRCON(16)
C
C        SELECT THE APPROPRIATE MODEL
C
      GO TO (100,110,120), MODDOX
C
C        PHYTOPLANKTON MODEI
C
100   SPRCAL(1)=(SPRIN(I,1)*COS(SPRIN(I,2)*T+SPRIN(I,3))+SPRIN(I,4)+COS(
     1SPRIN(I,2)*2*T+SPRIN(I,5)))*P
      RETURN
C
C        INDEPENDENT MODEL
C
110   SPRCAL(1)=SPRIN(I,1)*CUS(SPRIN(I,2)*T+SPRIN(I,3))+SPRIN(I,4)*COS(S
     1PRIN(I,2)*2*T+SPRIN(I,5))
      RETURN
C
C        ZERO MODFL
C
120   SPRCAL(1)=0.
C
```

```
      RETURN                                            52
      END                                               53-
      SUBROUTINE DOX (DO,RLC,RLN,RLD,DDODT)
C
C     THIS SUBROUTINE CALCULATES THE RATE OF CHANGE OF THE D.O.
C
      COMMON/BLK3/ALGIN,BENIN,BODIN,PHOIN,SPRIN,TOCIN,TOXIN,TININ
      COMMON/BLK4/ALGCAL,BENCAL,BODCAL,DOXCAL,REACAL,SPRCAL,TOCCAL,
     1            TOXCAL
      COMMON/BLK6/IZRCON
C
      DIMENSION ALGCAL(6),RENCAL(2),BODCAL(2),DOXCAL(2),
     1          SPRCAL(2),TOCCAL(2),TOXCAL(2)
      DIMENSION ALGIN(1,17),BENIN(1,2),BODIN(1,6),PHOIN(1,3),
     1          SPRIN(1,5),TOCIN(1,6),TOXIN(1,3),TININ(1,3)
      DIMENSION IZRCON(16)
C        CHECK FOR ZERO D.O. CONCENTRATION
100   IF (IZRCON(16)) 120,120,110
C        D.O. CONCENTRATION IS NOT ZERO
110   DDODT= BODCAL(1)*RLC-BODCAL(2)*RLN-BENCAL(1)*RLD+REACAL*(DOXCAL(1)
     1-DO)
      RETURN
C        D.O. CONCENTRATION IS ZERO
120   DDODT=0.
      IF (SPRCAL(1)) 140,140,130
130   DOXCAL(2)=REACAL*(DOXCAL(1)-DO)+SPRCAL(1)
      RETURN
C
140   IF ((BODCAL(1)*RLC+BODCAL(2)*RLN+BENCAL(1)*RLD).LE.0.0) GO TO 150
      DOXCAL(2)=REACAL*(DOXCAL(1)-DO)/(BODCAL(1)*RLC+BODCAL(2)*RLN+BENCA
     1L(1)*RLD)
      RETURN
150   DOXCAL(2)=0.0
C
      RETURN
      END
      SUBROUTINE BOD (RLC,RLN,DLCDT,DLNDT)
C
C     THIS SUBROUTINE CALCULATES THE RATE OF CHANGE OF THE BOD BASED
C     ON A FIRST ORDER REACTION.  TWO MODELS ARE POSSIBLE DEPENDING
C         ON THE VALUE OF MODBOD
C
C                  MODBOD
C                    1           BOTH CARBONACEOUS AND NITROGENOUS
C                                        BOD ARE CONSIDERED
C                    2           ONLY TOTAL BOD IS CONSIDERED
C
C         THE FOLLOWING NOMENCLATURE IS USED
C
C        BODIN(I,2).....SEDIMENTATION CONSTANT, K3
C        BODCAL(I,1)....DEOXYGENATION CONSTANT FOR CARBONACEOUS
C        BODCAL(I,2)....DEOXYGENATION CONSTANT FOR NITROGENOUS
C        RLC............CARBONACEOUS BOD CONCENTRATION
C        RLN............NITROGENOUS BOD CONCENTRATION
C        DLCDT..........CARBONACEOUS BOD DERIVATIVE
C        DLNDT..........NITROGENOUS  BOD DERIVATIVE
C
      COMMON/BLK1/I,J      I=SEGMENT, J =ELEMENT  (INDICES)
      COMMON/BLK2/MODALG,MODBOD,MODDOX,MODTIN,MODPHO
      COMMON/BLK3/ALGIN,BENIN,BODIN,PHOIN,SPRIN,TOCIN,TOXIN,TININ
      COMMON/BLK4/ALGCAL,BENCAL,BODCAL,DOXCAL,PHOCAL,SPRCAL,TOCCAL,
     1            TOXCAL
      COMMON/BLK6/IZRCON
C
      DIMENSION ALGCAL(6),BENCAL(2),BODCAL(2),DOXCAL(2),
     1          SPRCAL(2),TOCCAL(2),TOXCAL(2)
      DIMENSION ALGIN(1,17),BENIN(1,2),BODIN(1,6),PHOIN(1,3),
     1          SPRIN(1,5),TOCIN(1,6),TOXIN(1,3),TININ(1,3)
      DIMENSION IZRCON(16)
C
C         SELECT BOD MODEL
C
      GO TO (100,130), MODBOD
C
C         BOD MODEL WITH BOTH CARBONACEOUS AND NITROGENOUS BOD
C
C         CHECK IF D.O. IS LESS THAN OR EQUAL TO ZERO
100   IF (IZRCON(16)) 120,120,110
C         D.O. CONCENTRATION IS NOT ZERO
110   DLCDT=-(BODCAL(1)+BODIN(I,2))*RLC
      DLNDT=-(BODCAL(2))*RLN
      GO TO 160
C         D.O. CONCENTRATION IS ZERO
120   DLCDT=-(BODIN(I,2)+DOXCAL(2)*BODCAL(1))*RLC
      DLNDT=-DOXCAL(2)*RLN
      GO TO 160
C
```

```
C          BOD MODEL FOR TOTAL BOD
C
C          CHECK IF D.O. IS LESS THAN OR EQUAL TO ZERO
130    IF (IZRCON(16)) 150,150,140
C          D.O. IS NOT ZERO
140    DLCDT=-(BODCAL(1)+BODIN(I,2))+RLC
       DLNDT=0.
       GO TO 160
C          D.O. IS ZERO
150    DLCDT=-(BODIN(I,2)+DOXCAL(2)*BODCAL(1))+RLC
       DLNDT=0.
C
160    IF (IZRCON(5).LT.0) DLCDT=0.0
       IF (IZRCON(6).LT.0) DLNDT=0.
C
       RETURN
       END
```

```
      SUBROUTINE BEN (RLD,RLC,DLDDT)
C
C     THIS SUBROUTINE CALCULATES THE RATE OF CHANGE OF THE BENTHIC
C     BOD BASED ON A FIRST ORDER DEOXYGENATION WITH SEDIMENTATION
C     TERMS
C
C         THE FOLLOWING NOMENCLATURE IS USED
C
C                    BENCAL(1).... .DEOXYGENATION COEFFICIENT K4
C
      COMMON/BLK1/I,J      I=SEGMENT, J =ELEMENT  (INDICES)
      COMMON/BLK3/ALGIN,BENIN,BODIN,PHOIN,SPRIN,TOCIN,TOXIN,TININ
      COMMON/BLK4/ALGCAL,BENCAL,BODCAL,DOXCAL,REACAL,SPRCAL,TOCCAL,
     1           TOXCAL
      COMMON/BLK6/IZRCON
C
      DIMENSION ALGCAL(6),BENCAL(2),BODCAL(2),DOXCAL(2),
     1           SPRCAL(2),TOCCAL(2),TOXCAL(2)
      DIMENSION ALGIN(1,17),BENIN(1,2),BODIN(1,6),PHOIN(1,3),
     1           SPRIN(1,5),TOCIN(1,6),TOXIN(1,3),TININ(1,3)
      DIMENSION IZRCON(16)
C        CHECK THE DO CONCENTRATION
      IF (IZRCON(16)) 110,110,100
C        D.O. CONCENTRATION IS NOT ZERO
100   DLDDT=-BENCAL(1)*RLD+BODIN(I,2)*RLC
      GO TO 120
C        D.O. CONCENTRATION IS ZERO
110   DLDDT=+BODIN(I,2)*RLC-DOXCAL(2)*BENCAL(1)*RLD
C
120   IF (IZRCON(1).LT.0.) DLDDT=0.0
      RETURN
      END
      SUBROUTINE TOC (CT,CR,RLC,DCTDT,DCRDT)
C
C     THIS SUBROUTINE CALCULATES THE RATE OF CHANGE OF TOTAL ORGANIC
C     CARBON AND REFRACTORY ORGANIC CARBON BASED ON FIRST ORDER
C     REACTIONS
C
C         THE FOLLOWING NOMENCLATURE IS USED
C
C              TOCCAL(1) .....DEOXYGENATION CONSTANT FOR TOC
C
      COMMON/BLK1/I,J      I=SEGMENT, J =ELEMENT  (INDICES)
      COMMON/BLK3/ALGIN,BENIN,BODIN,PHOIN,SPRIN,TOCIN,TOXIN,TININ
      COMMON/BLK4/ALGCAL,BENCAL,BODCAL,DOXCAL,REACAL,SPRCAL,TOCCAL,
     1         TOXCH
      COMMON/BLK6/IZRCON
C
      DIMENSION ALGCAL(6),BENCAL(2),BODCAL(2),DOXCAL(2),
     1          SPRCAL(2),TOCCAL(2),TOXCAL(2)
      DIMENSION ALGIN(1,17),BENIN(1,2),BODIN(1,6),PHOIN(1,3),
     1          SPRIN(1,5),TOCIN(1,6),TOXIN(1,3),TININ(1,3)
      DIMENSION IZRCON(16)
C        CHECK D.O. CONCENTRATION
      IF (IZRCON(16)) 110,110,100
C        D.O. CONCENTRATION IS NOT ZERO
100   DCTDT=-(TOCCAL(1)+TOCIN(I,2))+TOCIN(I,3)*CT TOCIN(I,2)*CR
      DCRDT= TOCIN(I,2)
      GO TO 120
C        D.O. CONCENTRATION IS ZERO
110   DCTDT=-(DOXCAL(2)*TOCCAL(1)+TOCIN(I,2))*TOCIN(I,3)*CT-TOCIN(I,2)*C
     1R
      DCRDT=-TOCIN(I,2)
C        CHECK FOR ZERO CONCENTRATIONS
120   IF (IZRCON(8).LT.0) DCTDT=0.
      IF (IZRCON(7).LT.0) DCRDT=0.
C
      RETURN
      END
      SUBROUTINE TOX (TC,DTCDT)
C
C     THIS SUBROUTINE CALCULATES THE RATE OF CHANGE OF A TOXIC
C     COMPOUND USING AN  NTH - ORDER EQUATION
C
C         THE FOLLOWING NOMENCLATURE IS USED
C
C             TOXIN(1,2) . . . ORDER OF DECAY, N
C             TOXCAL(1)  . . . DECAY CONSTANT, A
C
      COMMON/BLK1/I,J      I=SEGMENT, J =ELEMENT  (INDICES)
      COMMON/BLK3/ALGIN,BENIN,BODIN,PHOIN,SPRIN,TOCIN,TOXIN,TININ
      COMMON/BLK4/ALGCAL,BENCAL,BODCAL,DOXCAL,REACAL,SPRCAL,TOCCAL,
     1           TOXCAL
      COMMON/BLK6/IZRCON
C
      DIMENSION ALGCAL(6),BENCAL(2),BODCAL(2),DOXCAL(2),
     1          SPRCAL(2),TOCCAL(2),TOXCAL(2)
      DIMENSION ALGIN(1,17),BENIN(1,2),BODIN(1,6),PHOIN(1,3),
     1          SPRIN(1,5),TOCIN(1,6),TOXIN(1,3),TININ(1,3)
      DIMENSION IZRCON(16)
C         CHECK FOR ZERO TOXIC CONCENTRATION
      IF (TC) 110,110,100
C         TOXIC CONCENTRATION IS NOT ZERO
100   DTCDT=-TOXCAL(1)*TC**TOXIN(I,2)
      GO TO 120
C         TOXIC CONCENTRATION IS ZERO
110   DTCDT=0.
C         CHECK FOR ZERO CONCENTRATION
120   IF (IZRCON(13).LT.0) DTCDT=0.
C
      RETURN
      END
      SUBROUTINE REARTN (J,NELEM,WIND,REACAL)
C
C     THIS ROUTINE CALCULATES THE AVERAGE REAERATION COEFFICIENT
C     FOR THE SURFACE ELEMENT.  A SIMPLE LINEAR RELATIONSHIP IS
C     POSTULATED TO ACCOUNT FOR REAERATION ON THE SURFACE.  OTHER FORMU-
C     LATIONS MAY BE USED AS THEORY OR DATA BECOME AVAILABLE.
C
      REACAL=0.0
      IF (J.NE.NELEM) RETURN
      A=1.0
      B=0.01
      REACAL=A+B*WIND
      IF (REACAL.LT.0.) REACAL=0.01
      IF (REACAL.GT.3.) REACAL=3.0
C
      RETURN



      SUBROUTINE TEMPER (TEMPR)
C
C     THIS SUBROUTINE CALCULATES THE TEMPERATURE CORRECTION FOR
C     THE RATE CONSTANTS USED IN THE OTHER SUBPROGRAMS.
C
      COMMON/BLK1/I,J      I=SEGMENT, J =ELEMENT  (INDICES)
      COMMON/BLK3/ALGIN,BENIN,BODIN,PHOIN,SPRIN,TOCIN,TOXIN,TININ
      COMMON/BLK4/ALGCAL,BENCAL,BODCAL,DOXCAL,REACAL,SPRCAL,TOCCAL,
     1            TOXCAL
C
      DIMENSION ALGCAL(6),BENCAL(2),BODCAL(2),DOXCAL(2),
     1          SPRCAL(2),TOCCAL(2),TOXCAL(2)
      DIMENSION ALGIN(1,17),BENIN(1,2),BODIN(1,6),PHOIN(1,3),
     1          SPRIN(1,5),TOCIN(1,6),TOXIN(1,3),TININ(1,3)
C
      TEMPR1=TEMPR-20.0
      BENCAL(1)=BENIN(I,1)*BENIN(I,2)**TEMPR1
      BODCAL(1)=BODIN(I,1)*BODIN(I,4)**TEMPR1
      BODCAL(2)=BODIN(I,5)*BODIN(I,6)**TEMPR1
      TOCCAL(1)=TOCIN(I,1)*TOCIN(I,6)**TEMPR1
      TOXCAL(1)=TOXIN(I,1)*TOXIN(I,3)**TEMPR1
C
      RETURN
      END
      SUBROUTINE LOAD (ID,NSEG,NL,DATA,VALUE)
C
C     THIS ROUTINE LOADS THE MODEL COEFFICIENTS AND ASSIGNS THE DEFAULT
C     VALUES AS AS NECESSARY.
C
      DIMENSION DATA(1,17),VALUE(1,17)
      DO 100 I=1,NSEG
      DO 100 K=1,NL
100   VALUE(I,K)=DATA(I,K)
      IF (ID.LE.0.OR.ID.GT.8) RETURN
C
C        SET DEFAULT VALUES
      GO TO (110,130,150,210,210,210,170,190), ID
C        ALGIN
110   DO 120 I=1,NSEG
      IF (VALUE(I,3).LE.0.0) VALUE(I,3)=1.0
      IF (VALUE(I,5).LE.0.0) VALUE(I,5)=1.0
      IF (VALUE(I,6).LE.0.0) VALUE(I,6)=1.0
      IF (VALUE(I,7).LE.0.0) VALUE(I,7)=1.0
      IF (VALUE(I,11).LE.0.0) VALUE(I,11)=1.0
120   CONTINUE
      RETURN
C        BODIN
130   DO 140 I=1,NSEG
      IF (VALUE(I,4).LE.0.0) VALUE(I,4)=1.0
      IF (VALUE(I,6).LE.0.0) VALUE(I,6)=1.0
140   CONTINUE
      RETURN
C        BENIN
150   DO 160 I=1,NSEG
      IF (VALUE(I,2).LE.0.0) VALUE(I,2)=1.0
160   CONTINUE
C        TOCIN
170   DO 180 I=1,NSEG
      IF (VALUE(I,6).LE.0.0) VALUE(I,6)=1.0
180   CONTINUE
      RETURN
C        TOXIN
190   DO 200 I=1,NSEG
      IF (VALUE(I,3).LE.0.0) VALUE(I,3)=1.0
200   CONTINUE
C
210   RETURN
      END
      SUBROUTINE ZERO (N1,N2,N3,N4,DATA)
C
C     THIS ROUTINE INTALIZES THE 'DATA' ARRAY.
C
      DIMENSION DATA(202,16)
C
      IF (N1.LF.0.OR.N2.LE.0.OR.N3.LE.0.OR.N4.LE.0) RETURN
      DO 100 J=N1,N2
      DO 100 K=N3,N4
      DATA(J,K)=0.0
100   CONTINUF
C
      RETURN
      END
```

```
      SUBROUTINE AVERGE (NELEM,CTRIB,CCIN,QTRIB,QHIN)
C
C     THIS ROUTINE AVERAGES THE INFLOW CONCENTRATIONS INTO THE SEGMENT.
C
      DIMENSION CTRIB(16),CCIN(202,16),QTRIB(1),QHIN(202)
      DATA MAXCON/16/
C
      DO 100 K=3,MAXCON
      DO 100 J=1,NELEM
      CCIN(J,K)=(CCIN(J,K)*QHIN(J)+CTRIB(K)*QTRIB(1))/(QHIN(J)+QTRIB(1))
100   CONTINUE
C
      RETURN
      END
      SUBROUTINE PRINTS (JJ,NPRINT,DAYS,HOURS,NELEM,C,ICODE)
C
C     THIS SUBROUTINE WRITES THE OUTPUT TO THE LINEPRINTER
C
      DIMENSION C(202,16)
      LL=0
      GO TO (100,110,120), ICODE
100   WRITE (6,200) JJ,DAYS,HOURS
      GO TO 130
110   WRITE (6,210) JJ,DAYS,HOURS
      GO TO 130
120   WRITE (6,220) JJ,DAYS,HOURS
130   DO 160 J=1,NELEM
      IF ((J/NPRINT*NPRINT.NE.J).AND.(J.NE.1).AND.(J.NE.NELEM))
     1   GO TO 160
      LL=LL+1
      WRITE (6,170) J
      GO TO (140,150,140), ICODE
140   WRITE (6,190) (C(J,KC),KC=1,8)
      WRITE (6,190) (C(J,KC),KC=9,16)
      IF (LL/30*30.EQ.LL.AND.ICODE.EQ.1) WRITE (6,200) JJ,DAYS,HOURS
      IF (LL/30*30.EQ.LL.AND.ICODE.EQ.3) WRITE (6,220) JJ,DAYS,HOURS
      GO TO 160
150   WRITE (6,180) (C(J,KC),KC=3,9)
      WRITE (6,180) (C(J,KC),KC=10,16)
      IF (LL/30*30.EQ.LL) WRITE (6,210) JJ,DAYS,HOURS
160   CONTINUE
      RETURN
C
170   FORMAT (I6)
180   FORMAT (1H ,20X,7(6X,1PE9.3))
190   FORMAT (1H ,10X,8(6X,1PE9.3))
200   FORMAT (1H1,//56X,'INITIAL CONDITIONS',//' SEGMENT',2X,I4,10X,'TIM
     1E',F4.0,' DAYS',4X,F5.2,' HOURS',//'  ELEMENT ',7X,'BEN',12X,'SED'
     2,12X,'SOL',12X,'ORG',12X,'CAR',12X,'NIT',12X,'REF',12X'TOC',/3X,'N
     3O.',11X,'BOD',11X,'PHOS',11X,'PHOS',11X,'PHOS',12X,'BOD',12X,'BOD'
     4,13X,'OC',/15X,115(1H-)//17X,'NH3',12X,'NO2',12X,'NO3',12X,'ORG N'
     5,9X,'TOXIC',10X,'PHYTO',11X,'ZOO',13X,'D.O.',/1X,130(1H-),/)
210   FORMAT (1H1,//51X,'UPSTREAM INFLOW CONCENTRATIONS'//' SEGMENT',2X,
     1I4,10X,'TIME',F4.0,' DAYS',4X,F9.2,' HOURS'//28X,'SOL',12X,'ORG',1
     22X,'CAR',12X,'NIT',12X,'REF',12X,'TOC',12X,'NH3'/27X,'PHOS',11X,'P
     3HOS',12X,'BOD',12X,'BOD',13X,'OC'/25X,100(1H-)//28X,'NO2',12X,'NO3
     4',11X,'ORG N',8X,'TOXIC',10X,'PHYTO',12X,'ZOO',13X,'DO'/25X,100(1H
     5-)//)
220   FORMAT (1H1,//,56X,'SIMULATION RESULTS'//' SEGMENT',2X,I4,10X,'TIM
     1E',F4.0,' DAYS',4X,F5.2,' HOURS',//'  ELEMENT ',7X,'BEN',12X,'SED'
     2,12X,'SOL',12X,'ORG',12X,'CAR',12X,'NIT',12X,'REF',12X'TOC',/3X,'N
     3O.',11X,'BOD',11X,'PHOS',11X,'PHOS',11X,'PHOS',12X,'BOD',12X,'BOD'
     4,13X,'OC',/15X,115(1H-)//17X,'NH3',12X,'NO2',12X,'NO3',12X,'ORG N'
     5,9X,'TOXIC',10X,'PHYTO',11X,'ZOO',13X,'D.O.',/1X,130(1H-),/)
      END
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APPENDIX C

USER'S MANUAL

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